TECHNICAL MEMORANDUM

PRELIMINARY WATER QUALITY AND TROPHIC STATE ASSESSMENT OF THE UPPER KISSIMMEE CHAIN OF LAKES, FLORIDA, 1981-82

FIRST ANNUAL REPORT

DRE - 167

B. L. Jones, P. S. Millar, T. H . Miller,
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INTRODUCTION

The Upper Kissimmee Chain of Lakes Limnetic and Material Budget Study is a five year water quality study of Lakes East Tohopekaliga, Tohopekaliga, Cypress, Hatchineha, and Kissimmee (Fig. 1). The general purpose of this program is to establish a limnetic and tributary water chemistry data base for the major lakes in the Upper Kissimmee River Basin. Specifically, the water chemistry data will be used along with the necessary hydrological data to:

(1) Identify spacial variations and temporal trends in lake water quality and relate lake water quality to tributary water quality. Investigate the effects of the discharge from one lake on the water quality of a receiving lake downstream.

(2) Relate inflow water quality to generalized land use. Determine nutrient loadings from each major source including surface waters (point and nonpoint source estimates), rainfall, and groundwater. Calculate nutrient budgets for each lake.

(3) Assess the trophic state and eutrophication potential of each lake. Compute maximum allowable nutrient loading rates for each lake by means of an input-output model. Prioritize management strategies.

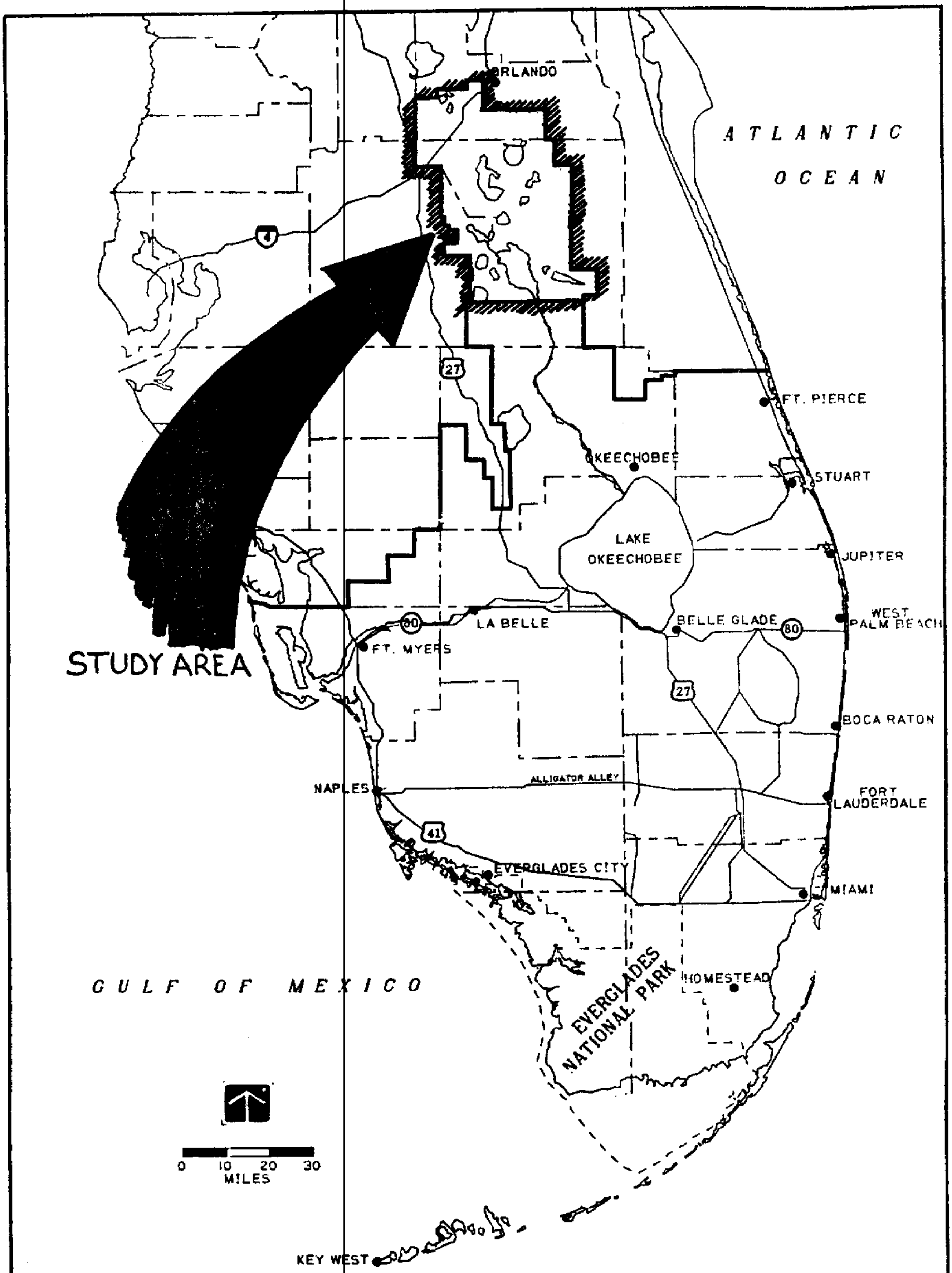


Fig. 1. Location of Upper Kissimmee Basin

This program began in FY 1980-81 with a comprehensive literature survey of water quality studies conducted in the Kissimmee Basin and the creation of a hydrological and water quality monitoring network for Lake Tohopekaliga and East Lake Tohopekaliga. In October 1981, the routine monitoring of these two lakes was initiated. Also during FY 1981-82, the monitoring network was expanded to include Lakes Cypress, Hatchineha, and Kissimmee. Although routine collection of hydrology and water quality data from these lakes and their tributaries did not begin until October 1982, some reconnaissance sampling was conducted on these lakes in the spring and summer of 1982. Currently, monitoring of all five lakes is continuing and is scheduled to end in September 1984, resulting in three complete years of data for the upper two lakes and two complete years of data for the lower three lakes.

This is the first annual report of the study. It is primarily concerned with the results of the first year of data collected from Lake Tohopekaliga and East Lake Tohopekaliga. However, some water quality data from Lakes Cypress, Hatchineha, and Kissimmee are also presented. The study results will be updated in a second report to be completed in April 1984. The final report on the project will be presented as a SFWMD Technical Publication scheduled for completion in May 1985.

The south Florida drought persisted through the earlier part of the first year of sampling. Consequently, there was not much flow into or out of these lakes until the spring of 1982. In contrast, heavy rains throughout the summer and fall resulted in considerable flow through the chain of lakes. This allowed the study of the upper two lakes during both dry and wet conditions. As will be shown in the results, these inflows exerted a major influence on lake water quality.

SUMMARY AND FINDINGS

This report contains preliminary results from the first year of the Kissimmee Chain of Lakes Limnetic and Material Budget Study. Lake Tohopekaliga, East Lake Tohopekaliga, and their tributaries were sampled monthly from October 1981 to September 1982. A hydrologic data collection network was established so that water and material budgets could be calculated. Water samples were also collected from Lakes Cypress, Hatchineha, and Kissimmee from April to September. The major findings are as follows:

I. Tributary Water Quality

1. Phosphorus levels in Shingle Creek were appreciably lower than historic levels. Although it is premature to conclusively determine the cause for this improved ambient quality, a contributing factor appears to be the reduced phosphorus levels in the wastewater discharges from the McLeod and Sand Lake Roads wastewater treatment plants.
2. The highest nitrogen and phosphorus concentrations were recorded at the West Kissimmee City Ditch and the Judges Dairy site, tributaries to Lake Tohopekaliga.

II. Water and Material Budget

1. The major inflows to East Lake Tohopekaliga were Boggy Creek, rainfall, and S-62, which together represented 89% of the total inflow. Boggy Creek contributed the most phosphorus (49%) while rainfall contributed the most nitrogen (33%).
2. The major source of water to Lake Tohopekaliga was Shingle Creek (41%), followed by rainfall (23%) and the St. Cloud Canal (22%). These inflows, collectively, contributed almost 90% to the total

inflow. Shingle Creek contributed the most phosphorus (65%) and nitrogen (41%).

3. The nitrogen and phosphorus loads associated with the discharge of sewage treatment plant effluent into Shingle Creek were equivalent to 76% and 42%, respectively, of the total nitrogen and phosphorus loads attributable to the creek.

4. Controllable nonpoint sources and point sources accounted for approximately equal amounts (48 and 42%, respectively) of the total phosphorus load to Lake Tohopekaliga. Point sources contributed the most nitrogen (41%) while controllable nonpoint sources contributed the least (23%).

III. Limnetic Water Quality

1. Lake Tohopekaliga displayed substantially higher levels of nitrogen (2.33 mg/L), phosphorus (0.303 mg/L), conductivity (269 micromhos/cm), and chlorophyll a (68.3 mg/m^3) than East Lake Tohopekaliga (0.72 mg/L, 0.020 mg/L, 145 micromhos/cm, and 5.3 mg/m^3, respectively).

2. While East Lake Tohopekaliga is fairly homogeneous, water quality varies in Lake Tohopekaliga, generally increasing from north to south for total nitrogen, chlorophyll a, turbidity, and decreasing for color and ortho and total phosphorus.

3. Inorganic nitrogen to orthophosphorus ratios suggested that East Lake Tohopekaliga is nitrogen limited; however, most observations for inorganic nutrients were below detection. Ratios of Total P to Total N indicated phosphorus limitation. In Lake Tohopekaliga the ratios of both the inorganic and total constituents suggested that the lake is most likely nitrogen limited.

4. There is a tendency for both inorganic nitrogen and orthophosphorus to convert to the organic form in the south end of Lake Tohopekaliga. There is evidence that nitrogen is being added to the system by either internal cycling or nitrogen fixation. Large blooms of Anabena sp. and Anacystis have been documented in the south end of Lake Tohopekaliga. The former is a nitrogen fixer, and both are considered indicators of highly eutrophic lakes.
5. In Lake Tohopekaliga, lakewide monthly averages of phosphorus, nitrogen, and chlorophyll a levels have been decreasing over the last two years. More data are necessary to determine whether this decline is in response to reduced Shingle Creek phosphorus concentrations or is a cyclical phenomenon.

IV. Trophic state Assessment and Model Evaluation

1. Trophic state indicators and trophic state indices classify East Lake Tohopekaliga as mesotrophic and Lake Tohopekaliga as eutrophic to hypereutrophic.
2. The modified Vollenweider (1976) model overestimated the average East Lake Tohopekaliga phosphorus concentration and significantly underestimated total phosphorus for Lake Tohopekaliga. Other input-output models performed similarly. For Lake Tohopekaliga, part of the error may be due to the inaccuracy of the Lake Tohopekaliga water budget. Spacial and temporal variations could also contribute to model error. In the future, this model should be evaluated along with other models to determine the best model(s) for these lakes.
3. Determining maximum allowable nitrogen loading rates to Lake Tohopekaliga will be difficult unless internal nitrogen loadings are

quantified and incorporated in the nitrogen loading model and an improved water budget is available.

4. Because lake chlorophyll is significantly correlated with phosphorus and nitrogen concentrations, future chlorophyll levels might be predicted from future nutrient loading rates.

MATERIALS AND METHODS

A list of surface inflow/outflow quality stations for East Lake Tohopekaliga and Lake Tohopekaliga is given in Table 1. The locations of all water quality stations are shown in Fig. 2. In addition to the major tributaries, several urban and rural ditches were sampled to gain information on runoff quality from the small watersheds around these lakes. Also, three shallow groundwater wells (~15 ft.) were sampled around each lake to determine the water quality of seepage inflows, and a rainfall quality station was located in Kissimmee to estimate the quality of precipitation falling directly on the lakes. Lake water quality was determined by sampling four stations in East Lake Tohopekaliga and nine stations in Lake Tohopekaliga. Lake Tohopekaliga was sampled more intensively because of previously identified areal variations in water quality.

Different techniques were used to estimate flow from the tributaries (Table 1). Daily discharges from major tributaries and several minor inflows were calculated from continuous stage records. For most other inflows, instantaneous flow rates were measured with either floats or dye at the time of sample collection. At two stations, Judge's Dairy pump and Partin pump, discharge was estimated from the pump discharge rate and number of hours pumped.

Other hydrological measurements included groundwater seepage, rainfall, evaporation, and lake stage. Seepage was estimated by monthly measurements of groundwater levels in 16 piezometers. Rainfall was determined from three stations around East Lake Tohopekaliga and four stations around Lake Tohopekaliga. Evaporation pan data collected at Kissimmee was used to

TABLE 1. SURFACE INFLOW/OUTFLOW WATER QUALITY STATIONS

Map I.D.	Name	Hydrology
East Lake Tohopekaliga		
1	S-62	SFWMD stage recorder
2	Jim Branch	SFWMD stage recorder
3	Boggy Creek	USGS stage recorder
4	Dakota Ditch	Instantaneous velocity measurements (dye method) 1/
5	S-59 (outflow)	SFWMD stage recorder
Lake Tohopekaliga		
6	Mill Slough	SFWMD stage recorder
7	East Kissimmee City Ditch	SFWMD stage recorder
8	West Kissimmee City Ditch	SFWMD stage recorder
9	Judge's Dairy Pump	SFWMD pump timer
10	Partin Canal	SFWMD stage recorder
11	Shingle Creek - West	USGS stage recorder
12	Shingle Creek - East	None - assumed to be same as #1 above
13	Partin Pump	SFWMD pump timer
14	St. Cloud Canal - South	Assumed equal to S-59 discharge plus discharge from St. Cloud STP
15	Pleasant Hill Ditch	Instantaneous velocity measurements (float method) 1/
16	Overstreet Ditch	Instantaneous velocity measurements (float method) 1/
17	Johnson Ditch	Instantaneous velocity measurements (float method) 1/
18	Whaley Ditch	Instantaneous velocity measurements (float method) 1/
19	Partin Ditch-North	Instantaneous velocity measurements (float method) 1/
20	Partin Ditch - South	Instaneaneous velocity measurements (float method) 1/
21	S-61 (outflow)	SFWMD stage recorder

1/ Flow measured at time of sample collection

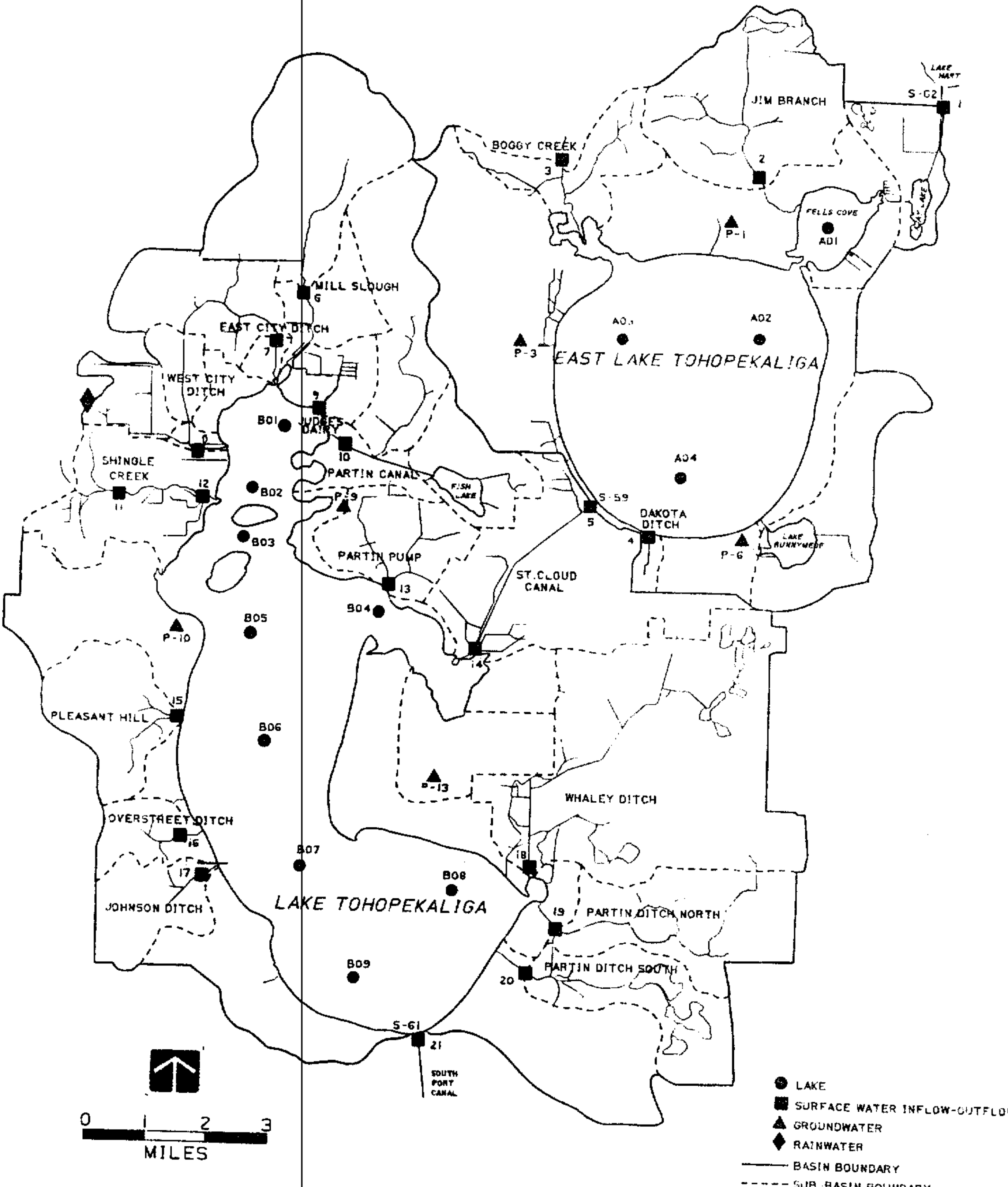


Fig. 2. Lake Tohopekaliga and East Lake Tohopekaliga Sampling Stations

estimate lake evaporation. An evaporation pan coefficient of 1.0 was used. East Tohopekaliga lake stage was measured at S-59 and S-62. The stage of Lake Tohopekaliga was measured at S-61 and at a U.S.G.S. recorder located in the north end. The interpretation of hydrological data and the preparation of water budgets were performed by the SFWMD Water Resources Division.

Because hydrological data were collected at varying frequencies, various methods had to be used to calculate nutrient loadings from each inflow. Appendix A details the methodology used to calculate loadings from surface inflows, point source discharges, rainfall, and seepage.

The parameters sampled and the frequencies of collection are shown in Table 2. Lake and tributary stations were monitored monthly for most parameters. Groundwater stations were sampled quarterly. Rainwater samples were collected daily, frozen, and composited over a month-long period.

Samples from lakes and tributaries were taken within 0.5 meters of the water surface. Dissolved oxygen, temperature, pH, and specific conductance were measured *in situ* with a Hydrolab Series 8000(R). Samples were placed in acid-rinsed plastic bottles (filtered if required) and transported on ice to the laboratory for analysis. Standard SFWMD sampling and analytical procedures are described in more detail by Federico et al. (1981).

In addition to the above, phytoplankton samples were collected in April and August 1982 to determine algal species and abundance. Composite samples were collected from surface and 2.0 meter depths. Samples were analyzed by the SFWMD Environmental Sciences Division.

Primary productivity was measured in August at two sites in Lake Tohopekaliga. The light and dark bottle technique used was described by Marshall (1977). Bottles were suspended at 0.2 and 2.0 meter depths and incubated for six hours.

TABLE 2. WATER QUALITY PARAMETERS AND SAMPLING FREQUENCIES

Station Type	Sampling Frequency	Parameters
Lakes and Tributaries	Monthly	NO_3, NO_2, NH_4, TKN, ortho and total P, alkalinity, Cl, TOC, turbidity, pH, conductivity, D.O., temperature, color
		Secchi depth, chlorophyll a (lakes only)
	Quarterly (December, March, June, September)	SO_4, total Fe, total susp. solids, Na, K, Ca, Mg, hardness, SiO_2, F
	Semi-yearly (February, August)	Trace metals
Groundwater	Quarterly	NO_3, NO_2, NH_4, TdKN, ortho and total dissolved P, alkalinity, Cl, conductivity, color, Na, K, Ca, Mg, hardness, SO_4, pH
Rainwater	Daily collection Monthly composites	NO_3, NO_2, NH_4, TKN, ortho and total P, Cl, conductivity

RESULTS AND DISCUSSION

Tributary Water Quality

Introduction

This section will describe the general water quality characteristics of the lakes' inflows and outflows and will be followed by a section describing the flow-weighted nutrient concentrations. Rainfall and groundwater quality will also be provided.

A complete data set is available for the East Lake Tohopekaliga tributaries and many of the Lake Tohopekaliga tributaries. Certain tributary stations to Lake Tohopekaliga have incomplete data sets due either to insufficient water to sample (Johnson Ditch, Pleasant Hill Estates, and Overstreet Ditch), to changes in the station location (West Shingle Creek site), or to canal improvements which prevented sample collection (Judges Dairy).

General Water Quality

East Lake Tohopekaliga:

Generally, the water delivered to East Lake Tohopekaliga was soft and low in dissolved solids as indicated by the low specific conductance and the low levels of cations and anions. The sampled tributaries were generally acidic with average pH levels ranging from a low at Jim Branch of 4.4 units to a high of 6.4 units at the Boggy Creek site. The acidic pH levels probably result from the leaching of organic acids from the relatively undisturbed natural watersheds surrounding East Lake Tohopekaliga, especially in the north (Kaufman, 1970). Average color was lowest in the St. Cloud area (50 Pt units) and highest at the Jim Branch site (307 Pt units).

The daytime dissolved oxygen levels were consistently above 5.0 mg/L for the Boggy Creek and S-62 sites. The Dakota Ditch and Jim Branch sites both had average dissolved oxygen values and discrete values less than the 5.0 mg/L standard for Class III receiving waters (FAC Chapter 17-3).

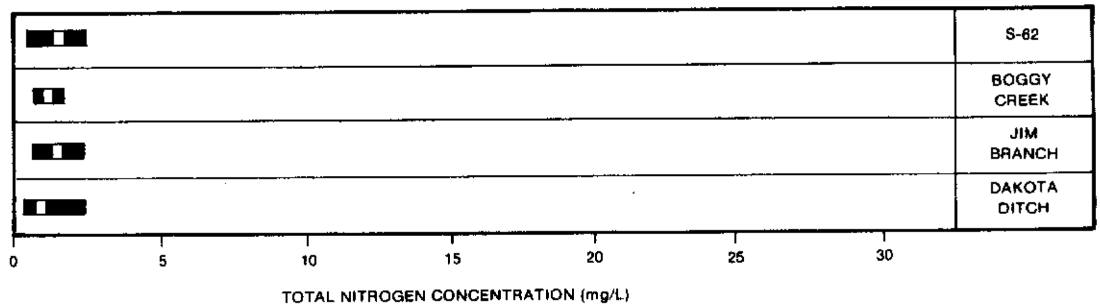
Average turbidity, suspended solids, and most heavy metals were very low in all the tributaries. Dissolved manganese was comparatively higher at the Jim Branch site (18.0 micrograms/L).

Average total nitrogen concentrations in the tributaries ranged from a low of 0.78 mg/L at the Dakota Avenue site in St. Cloud to a high of 1.51 mg/L at S-62 in Lake Hart (Fig. 3). Among all stations, from 3% to 15% of the nitrogen was in the inorganic form. Boggy Creek had almost equal levels of nitrate and ammonium while the Dakota Avenue Ditch site and the Jim Branch site had a higher percentages of ammonium (67% and 80%, respectively). The inorganic nitrogen levels at the S-62 site were predominantly nitrate (73%).

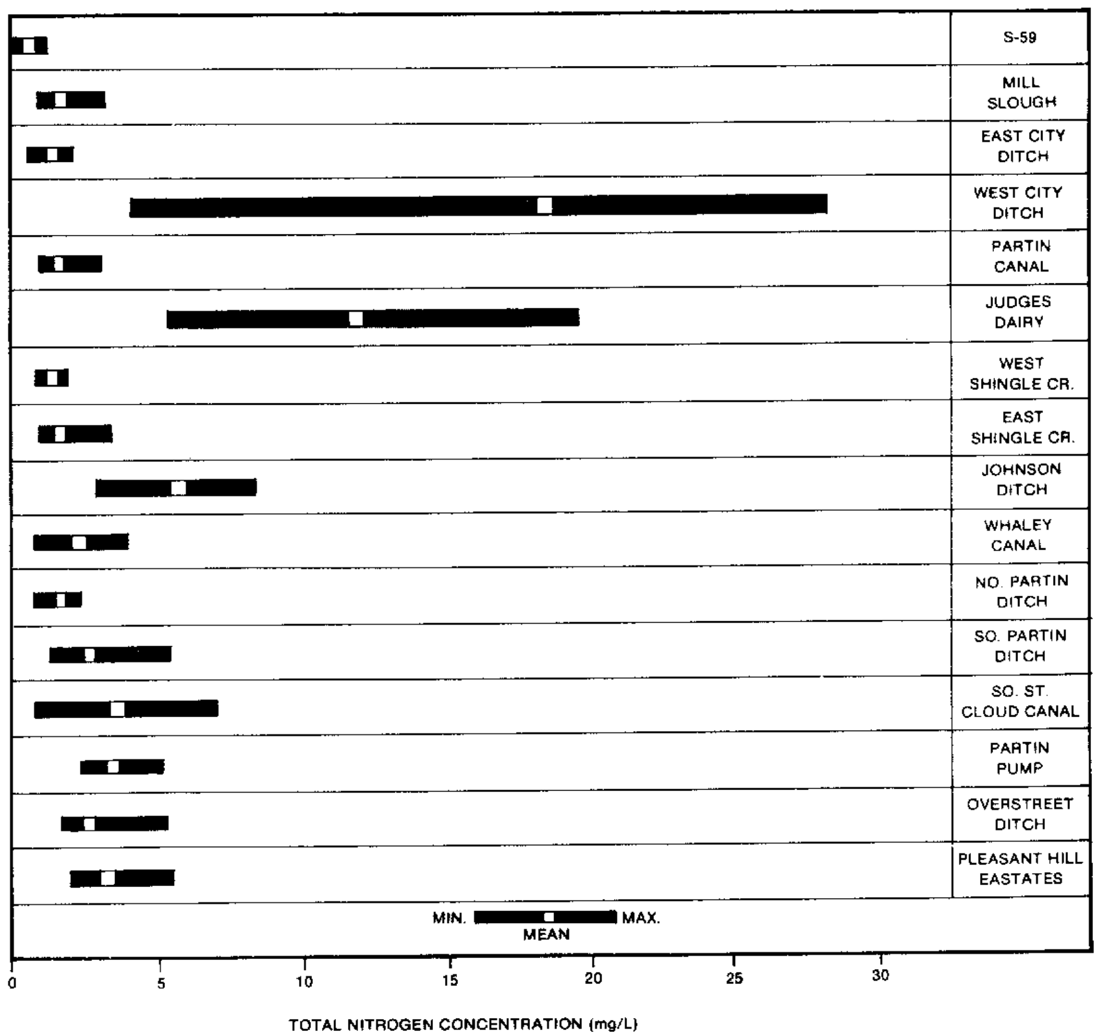
The highest mean total phosphorus concentration was measured at Boggy Creek (0.129 mg/L). Station S-62 had the lowest values, averaging 0.034 mg/L (Fig. 4). Appendix B presents a summary of the average water quality data for the tributaries, rainfall, and groundwater around East Lake Tohopekaliga.

Lake Tohopekaliga

Generally, the inflows to Lake Tohopekaliga were soft to moderately hard. The average specific conductance ranged from a low of 142 micromhos/cm at the North Partin Ditch to a high of 580 micromhos/cm at Judges Dairy. The tributaries were generally acidic with average pH values ranging from a low of 4.2 units at the Johnson Ditch site to a high of 7.1 units at the West Kissimmee City Ditch site.

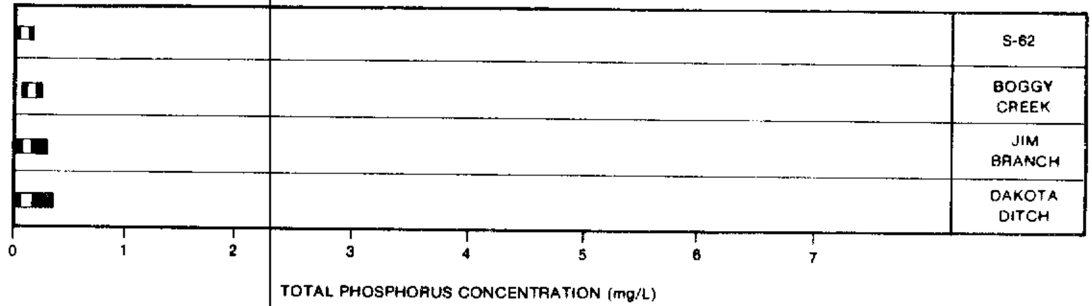


EAST LAKE TOHOPEKALIGA TRIBUTARIES

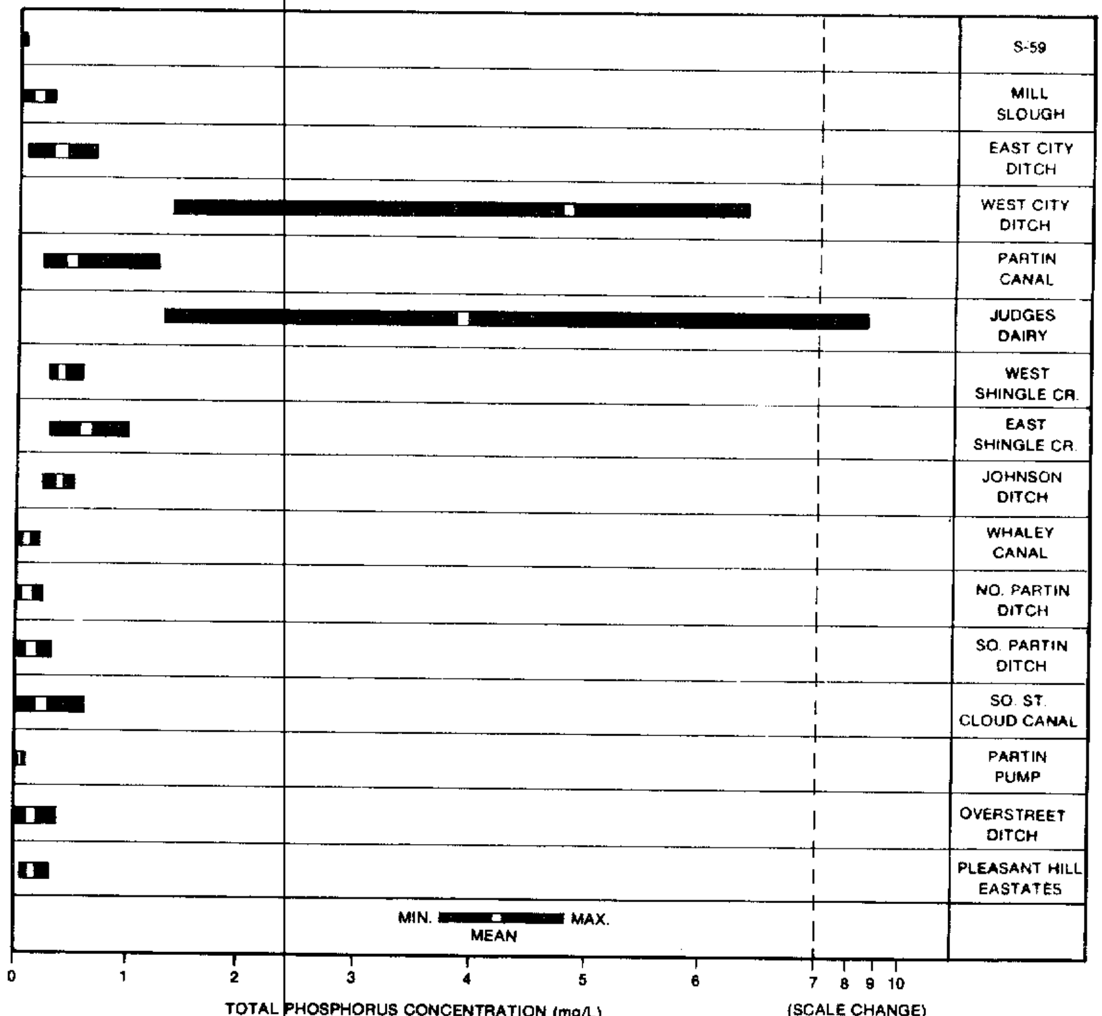


LAKE TOHOPEKALIGA TRIBUTARIES

Fig. 3 TOTAL NITROGEN CONCENTRATION FOR THE EAST LAKE TOHOPEKALIGA AND LAKE TOHOPEKALIGA TRIBUTARIES (1981-1982)



EAST LAKE TOHOPEKALIGA TRIBUTARIES



LAKE TOHOPEKALIGA TRIBUTARIES

Fig. 4 TOTAL PHOSPHORUS CONCENTRATION FOR THE EAST LAKE TOHOPEKALIGA AND LAKE TOHOPEKALIGA TRIBUTARIES (1981-1982)

Color exhibited extreme variability ranging from a low of 40 Pt units at structure S-59 to a high of 977 Pt units at the Johnson Ditch site. The color of the tributary water appears lower in the mostly urban and developing urban sites in the northern part of the lake basin and higher in the rural and undeveloped sites around the southern half of the lake.

Average daytime dissolved oxygen levels for all tributaries were less than the 5.0 mg/L criteria for Class III waters except the Shingle Creek sites (West, 6.2 mg/L; east, 6.9 mg/L), Mill Slough (6.3 mg/L), S-59 (6.3 mg/L), the North Partin Ditch (5.0 mg/L), and the St. Cloud Canal (5.8 mg/L). The Shingle Creek sites were the only sites which consistently had dissolved oxygen levels greater than 5.0 mg/L.

Levels of turbidity and suspended solids were generally low. The average total suspended solids level at Judges Dairy (51.0 mg/L) is probably not representative because ditch bank and canal improvements were taking place during part of the study period.

Most of the heavy metal concentrations were quite low. However, the West Kissimmee City Ditch downstream of the Kissimmee main wastewater treatment plant did have relatively high levels of copper and manganese, and higher levels of lead than any of the other tributaries to Lake Tohopekaliga.

Average total nitrogen concentrations in the tributaries to Lake Tohopekaliga ranged from a low of 0.80 mg/L at structure S-59, upstream in East Lake Tohopekaliga, to a high of 18.50 mg/L in the West Kissimmee City Ditch, downstream of the Kissimmee main wastewater treatment plant (Fig. 3). Among most stations, less than 20% of the total nitrogen was due to inorganic nitrogen. The inorganic levels exceeded 20% at the South Partin Ditch site (22%), the Judges Dairy site (59%), the St. Cloud Canal site downstream from the City of St. Cloud wastewater treatment plant discharge (61%), and the West

Kissimmee City Ditch site (78%). The inorganic nitrogen at the Shingle Creek, Mill Slough, the St. Cloud Canal, and the North Partin Ditch sites was composed of mostly nitrate. Inorganic nitrogen at the other stations was predominantly ammonium.

The highest average total phosphorus levels were measured at the West Kissimmee City Ditch (4.789 mg/L) and at Judges Dairy (3.836 mg/L), both of which exceeded the next highest mean phosphorus concentration (Shingle Creek east site, 0.550 mg/L) by more than six times (Fig. 4). The lowest total phosphorus average was recorded at station S-59 (0.031 mg/L). Orthophosphorus prevailed (∽50%) at all sites except the rural and agricultural sites (Pleasant Hill Estates, S-59, Whaley Canal, North and South Partin Ditch, Overstreet Ditch, and the Partin pump).

The average groundwater concentrations of inorganic nitrogen were high (5.34 mg/L). The high average concentration, however, is the result of extremely high nitrate levels at one site (BP-9) located on the northeast side of Lake Tohopekaliga. Nitrate at this one site averages 11.7 mg/L and was over 5 times greater than the combined average total dissolved nitrogen (TdKN + NO_x) concentration (2.2 mg/L) of the other two groundwater observation sites. It appears likely that fertilization practices may be contributing to the elevated nitrogen levels. The average orthophosphorus levels in groundwater were 0.052 mg P/L and less than the average surface water concentrations at most sampling sites. Appendix C shows the average water quality for the tributaries, groundwater, and rainfall around Lake Tohopekaliga.

Flow-Weighted Nutrient Concentrations

Flow-weighted nutrient concentrations for Lake Tohopekaliga and East Lake Tohopekaliga inflows were calculated by dividing the total mass of nutrients entering the lake by the annual discharge for the study period (Tables 8 and 10 in Water and Material Budget section). Flow-weighted nutrient concentrations are usually better estimates of the quality entering a lake since the water quality of many tributaries are affected by runoff events.

Partin Pump and Judges Dairy flow-weighted concentrations have not been computed for this study. Because of the method used to calculate discharge (see Appendix A), flow-weighted concentrations for these sites had little meaning.

East Lake Tohopekaliga

Flow-weighted total phosphorus and total nitrogen concentrations ranged from a high of 0.16 mg/L at the Dakota Ditch and 1.61 mg/L at Jim Branch, respectively, to a low of 0.03 mg/L at S-62 and 0.66 mg/L at the Dakota Ditch, respectively (Table 3). Very little difference was apparent between the average nutrient concentrations and the flow-weighted concentrations for any of the measured inflows. This indicates that there is apparently no strong relationship between the amount of discharge and the concentration of nutrients delivered to East Lake Tohopekaliga.

Lake Tohopekaliga

The highest flow-weighted concentrations for both phosphorus and nitrogen were at the West Kissimmee City Ditch (4.58 mg/L and 17.48 mg/L, respectively) and were due to high nutrient levels in the water discharged from the Kissimmee Main Wastewater treatment plant (Table 4). The next largest flow-weighted phosphorus concentration 0.45 mg/L (at Shingle Creek) was one order of magnitude less than at the West Kissimmee City Ditch. The lowest

TABLE 3. AVERAGE AND FLOW-WEIGHTED TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS FOR EAST LAKE TOHOPEKALIGA TRIBUTARY INFLOWS

	Total Phosphorus (mg/L)		Total Nitrogen (mg/L)	
Inflow	Average	Flow-weighted	Average	Flow-weighted
Boggy Creek	0.13	0.14	1.06	1.12
Rainfall	0.09	0.08	1.42	1.42
S-62	0.03	0.03	1.51	1.44
Seepage	0.04	0.04	1.79	1.58
Dakota Ditch	0.06	0.16	0.78	0.66
Jim Branch	0.12	0.08	1.45	1.61
Flow Weighted Average		0.08		1.36

TABLE 4. AVERAGE AND FLOW-WEIGHTED TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS FOR LAKE TOHOPEKALIGA TRIBUTARY INFLOWS

	Total Phosphorus (mg/L)		Total Nitrogen (mg/L)	
Inflow	Average	Flow-weighted	Average	Flow-weighted
Shingle Creek	0.55	0.45	1.85	1.62
St. Cloud Canal	0.25	0.11	3.63	1.01
Mill Slough	0.20	0.19	1.75	1.35
Johnson Ditch	0.35	0.20	5.60	5.78
S. Partin Ditch	0.17	0.08	2.63	2.24
N. Partin Ditch	0.07	0.06	1.60	1.41
E. Kissimmee Ditch	0.29	0.38	1.12	1.26
W. Kissimmee Ditch	4.79	4.58	18.50	17.48
Partin Canal	0.46	0.31	1.67	1.69
Seepage	0.38	0.10	5.95	5.82
Rainfall	0.09	0.08	1.42	1.42
Flow Weighted Average		0.28		1.61

flow-weighted nutrient concentrations occurred at the St. Cloud Canal structure, S-59, (phosphorus: 0.11 mg/L, nitrogen: 1.01 mg/L) and the North Partin Ditch (phosphorus: 0.06 mg/L; nitrogen: 1.41 mg/L).

The flow-weighted nutrient concentrations in the East Kissimmee City Ditch were slightly greater than the average annual nitrogen and phosphorus concentrations, while the Johnson Ditch and Partin Canal concentrations were slightly greater only for nitrogen. These differences, however, appear to be minor. For the remaining tributaries, the flow-weighted nutrient concentrations were less than the annual average concentration.

Previous studies (Federico and Brezonik 1975; Wanielista, 1976) have shown that Shingle Creek nutrient levels were usually reduced during higher flows. These reports suggested that a diluting of the normally high nutrient levels experienced during low flow, due to wastewater inflows, was due to the relatively lower nutrient levels characteristic of nonpoint source runoff. These data also suggest that same trend (Fig. 5).

The St. Cloud Canal appeared to be most affected by discharge judging from the relatively large differences between the flow-weighted averages and the average annual concentrations of nitrogen and phosphorus. The flow-weighted nitrogen (1.01 mg/L) and phosphorus (0.11 mg/L) concentrations were reduced to less than half the average annual concentrations. This reduction appears to be the result of discharge at S-59 which diluted the usually high concentration in the St. Cloud Canal (Fig. 6). During no or low flow conditions, nutrient concentrations in the St. Cloud Canal are high due to discharge into the canal from the St. Cloud wastewater treatment plant.

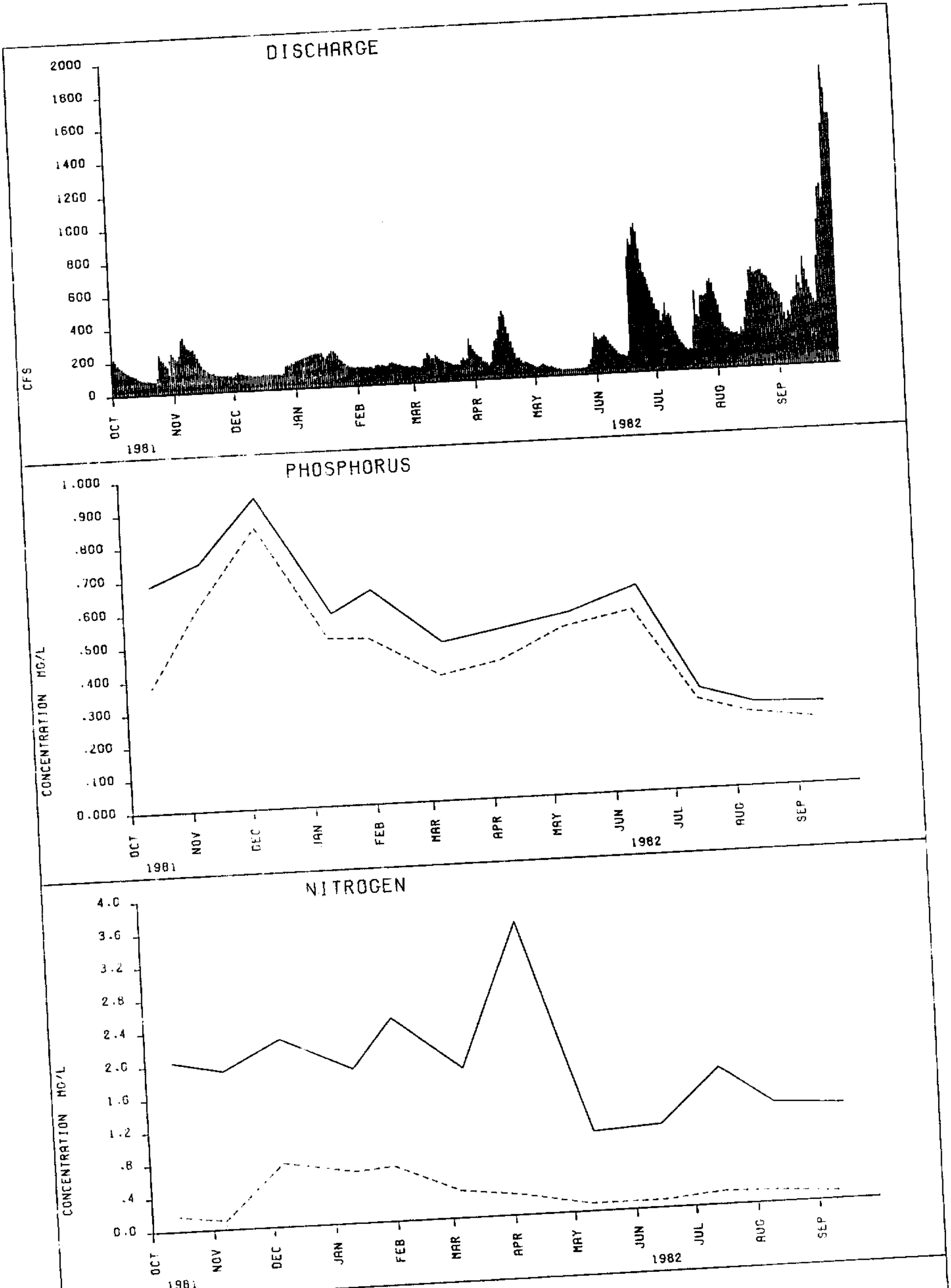


Fig. 5. Nutrient and Discharge Data for Shingle Creek

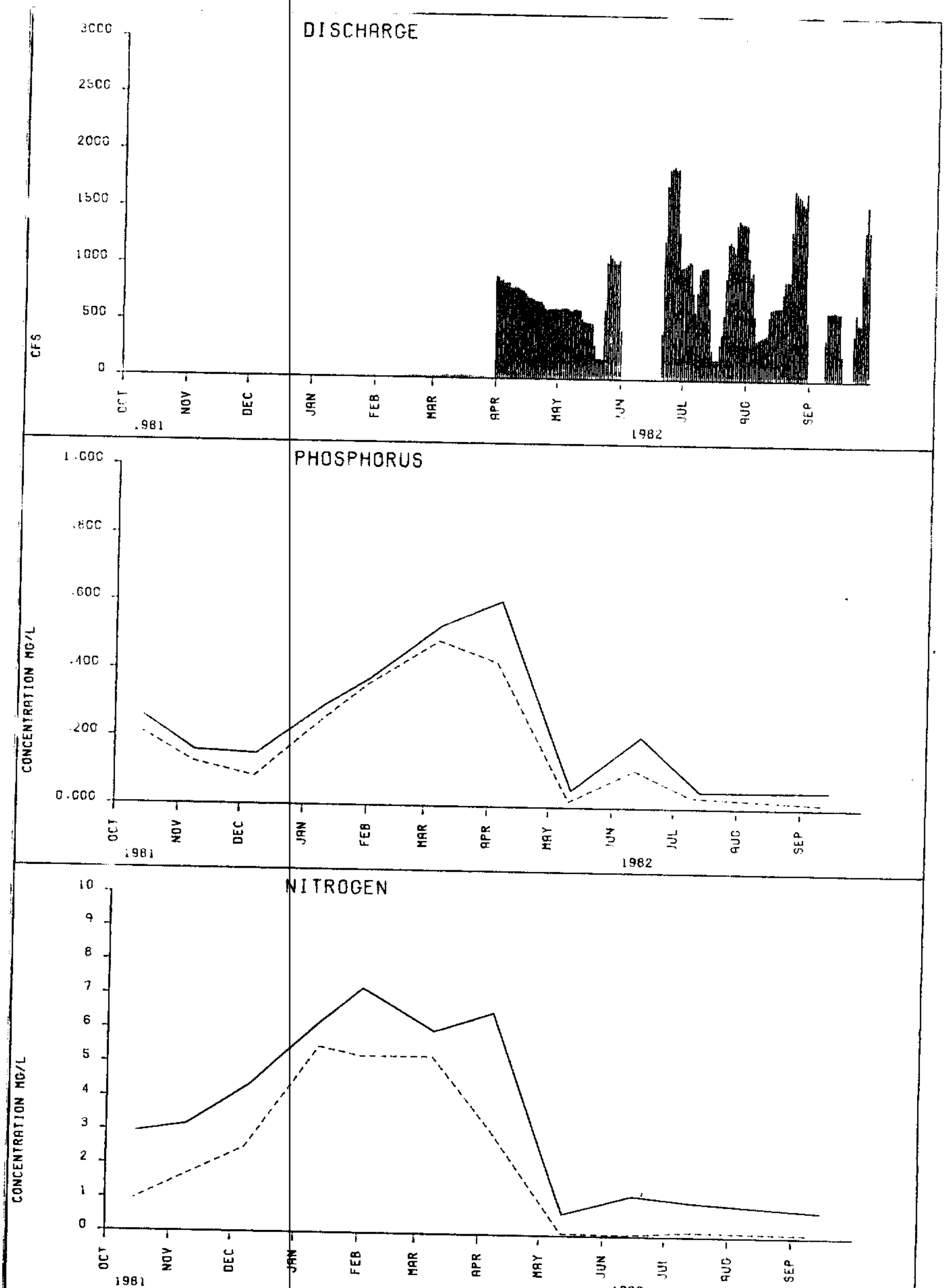


Fig. 6. Nutrient and Daily Discharge Data for the St. Cloud Canal

Shingle Creek Phosphorus Concentrations

The average total phosphorus concentration, presented earlier for Shingle Creek, was approximately 0.50 mg/L. The phosphorus levels measured during this study were appreciably lower than the historic levels reported by others (Table 5). While there were some minor differences in the frequencies of collection, the more important factors (analytical methods, sampling station locations) are comparable between studies. Figure 7 presents the monthly rainfall totals for the South Florida Water Management District's Kissimmee field station which is located in the same general vicinity as the U.S. Geological Survey recorders at Campbell and Kissimmee. The historic average and study period total rainfalls were seasonal with most of the rainfall occurring during the summer months. For the period of this study, total rainfall exceeded the average for the previous nine year period by more than 10 inches. Table 6 shows the annual discharges for Shingle Creek at Kissimmee and Campbell between 1973 and 1982. Discharges at both the Campbell site and the Kissimmee site during the study period were more than double the previous nine year average annual discharge. Assuming the additional ten inches of rainfall recorded at the Kissimmee field station were collected by the Shingle Creek Basin and the runoff reached Shingle Creek, flows of the magnitude shown during this study period (170,729 acre-feet) appear reasonable and might partially explain the reduced phosphorus concentrations in Shingle Creek. However, while previous studies have linked reduced phosphorus concentrations to wet periods and increased flows in Shingle Creek, these same studies have also linked a corresponding decrease in dissolved solids and major ions (Federico and Brezonik, 1975; Wanielista, 1976). Therefore, the decrease in phosphorus concentrations noted during this study should have been

TABLE 5. COMPARATIVE HISTORICAL WATER QUALITY DATA FOR SHINGLE CREEK 1/

Source/Date	Chloride mg/L	Total Nitrogen mg/L	Nitrate mg/L	Ammonia mg/L	Total Phosphorus mg/L	Ortho Phosphorus mg/L
This Study 2/ 1981-1982	25.8	1.74	0.182	0.043	0.505	0.422
Federico and Brezonik 2/ 1974	25.4	4.48	0.394	0.324	1.771	1.493
OCPCD/ 1970-1973	-	-	0.19	0.215	3.28	-
Phelps/ 1969-1980	29.0	1.7	0.25	0.17	1.5	1.3
Milleson/ 1974	22.8	1.21	0.087	0.04	1.555	1.207
USGS/ 1979	27.0	1.34	0.105	0.04 3/	1.500	1.48 3/
USGS/ 1980	43.0	1.92	0.560	0.06 3/	1.805	1.787 3/
DER/ 1974-1978	29.0	1.4	0.19	0.16	1.5	-

1/ All stations selected are located between U.S. Hwy 192 near Kissimmee and Lake Tohopekaliga

2/ Combined average of two stations

3/ Total values

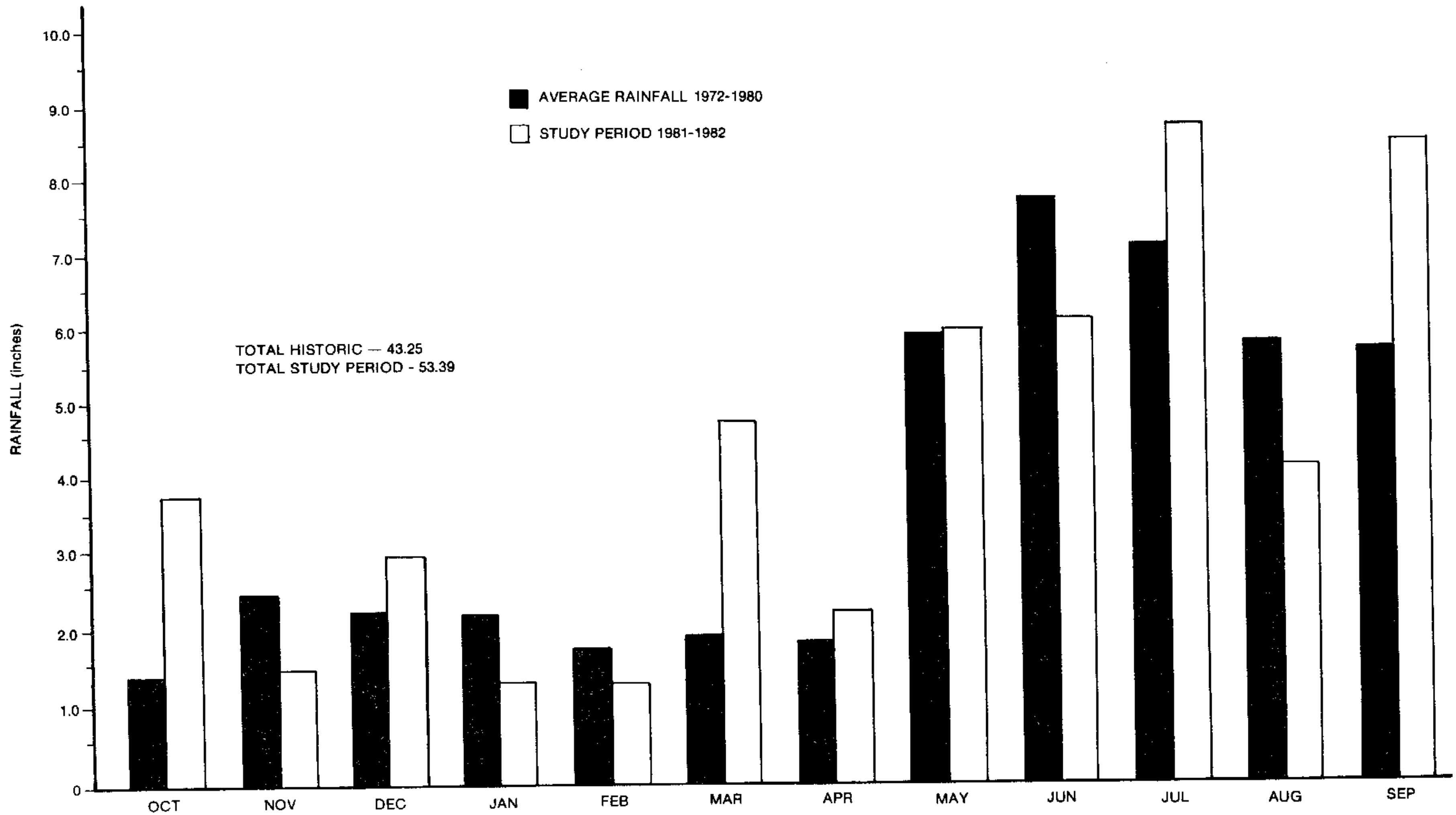


Fig. 7 RAINFALL AT KISSIMMEE FIELD STATION

TABLE 6. DISCHARGE COMPARISONS FOR SHINGLE CREEK

Year	Discharge* at Campbell (02264495)	Discharge* at Kissimmee (02263800)
1973	97,740	49,640
1974	107,100	68,130
1975	74,360	43,730
1976	93,930	59,530
1977	61,440	32,510
1978	96,590	52,550
1979	102,200	57,210
1980	64,780	34,580
1981	64,920	34,630
Average Annual (1973-1981)	84,784	48,057
Study Period Total (1982)	170,729	97,394

* All discharges are in acre-feet

1973-1980 data from U.S.G.S. published data

1981-1982 provisional USGS unpublished data accompanied by a decrease in chloride and in nitrogen if dilution due to rainfall alone was responsible for the decreased phosphorus levels (Table 5). Since the ambient chloride and nitrogen concentrations in Shingle Creek were consistent with previous studies, some other contributing factor to the lowered phosphorus levels seems indicated.

Major sources of nutrients to Shingle Creek are the Sand Lake Road and McLeod Road wastewater treatment plants (Federico and Brezonik, 1975; U.S. EPA, 1980). The average monthly phosphorus concentrations in the effluent from these plants show a dramatic decrease since 1981 (Fig. 8) (FDER, 1982). The volume of wastes treated during this period has steadily increased such that each plant now processes about 100 cfs more than was processed during years prior to 1981. The improvements in the treatment of wastes at these two plants has led to a significant reduction in the phosphorus loads being discharged to Shingle Creek (Davenport, 1983). This reduced phosphorus load to Shingle Creek from the wastewater treatment plants should have contributed to the reduction in ambient nutrient levels within the surface water of Shingle Creek.

Table 7 analyzes the reduction in the phosphorus loadings attributable to the Sand Lake Road and McLeod Road wastewater treatment plants between the historic loads presented by the U.S. EPA (1980) and those computed in this study. This table shows that if the sewage treatment plants had not improved their treatment process, a phosphorus concentration in Shingle Creek of 0.72 mg/L would have been expected (assumingno assimilation in Shingle Creek). Comparing this concentration that wouldhave been expected in1982, assuming no improved treatment, with the averagephosphorus concentration measured between 1975 and 1979, it appears that 1/3 of the reduction in total phosphorus

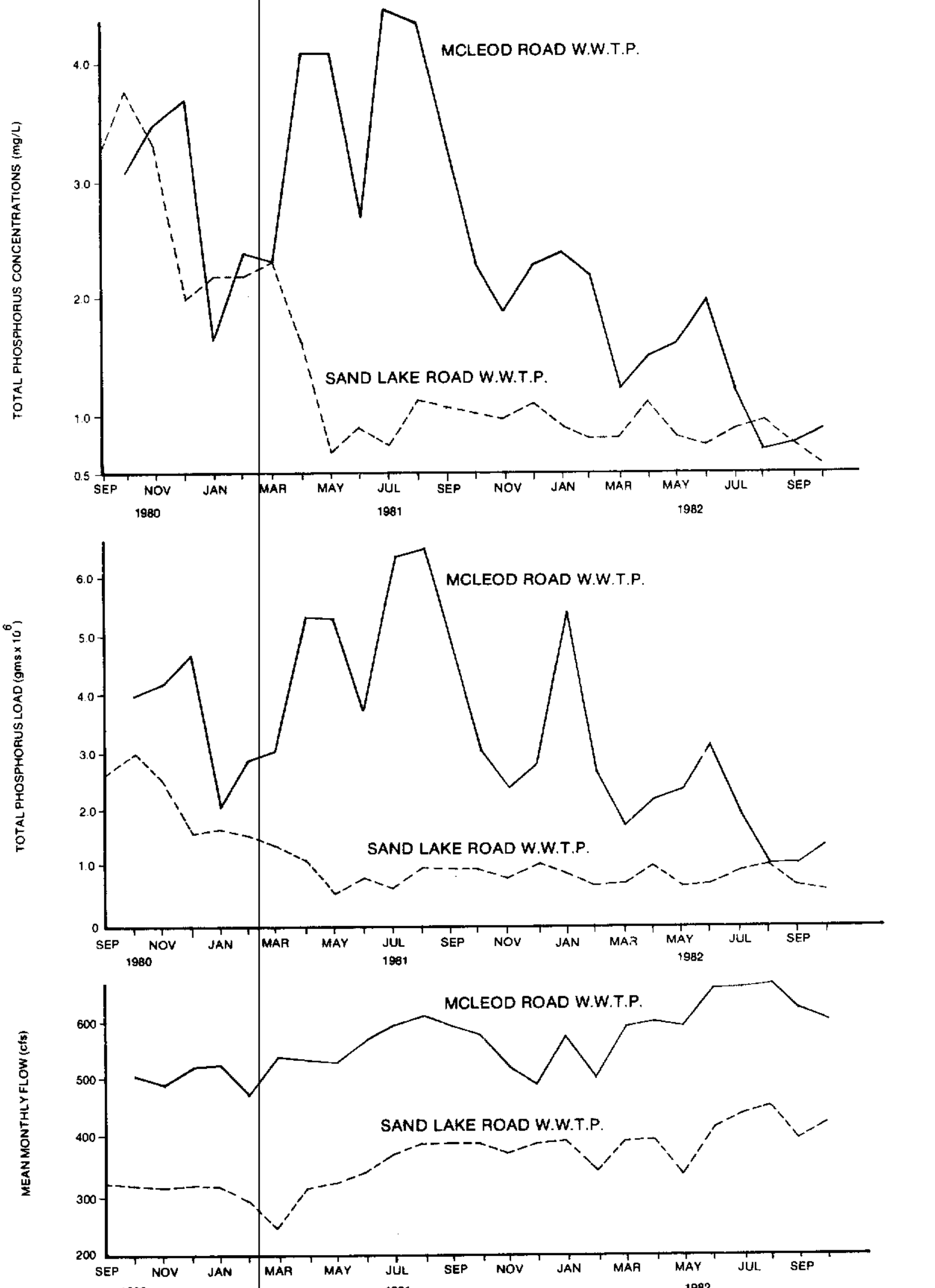


Fig. 8 MCLEOD ROAD AND SAND LAKE ROAD WASTE WATER TREATMENT PLANT PHOSPHORUS AND AVERAGE DISCHARGE DATA.

TABLE 7. ANALYSIS OF THE REDUCTION IN PHOSPHORUS LOADINGS ATTRIBUTABLE TO THE SAND LAKE AND MCLEOD ROAD WASTEWATER TREATMENT PLANTS

Date	Flow acre-feet	Mass Load (gms X 10^6)	Flow-Weighted Concentration (mg/L)	Comments
1975-1979 1/	88,242	135.3	1.28	Shingle Creek prior to 1980 WWTP improvements
1981-1982	170,729	95.1	0.45	Shingle Creek during this study after 1980 WWTP improvements
1981-1982	170,729	151.9 2/	0.72	Shingle Creek during 1981-1982 assuming no WWTP improvements

Percent reduction due to treatment plant improvements 33% 3/

1/ Data extracted from U.S. EPA, 1980.

2/ Phosphorus mass load computed by:

Shingle Creek Mass Load (1982) - WWTP load (1982) - WWTP Load (1975-1979)

Where: WWTP Load = Sand Lake Road and McLeod Road WWTP = 38.2 mg X 10^6

From Table

3/ Computed by ratio $\frac{0.72 - 0.45}{1.28 - 0.45}$ = Percent reduction of WWTP's concentration can be attributed to improved treatment plant operation. The remaining 2/3 cannot readily be explained by dilution since the chloride and nitrogen data showed no dilution effect due to the doubling of flow.

Water and Material Budget

Introduction

One of the major purposes of this study was to develop a comprehensive water and materials budget for East Lake Tohopekaliga and Lake Tohopekaliga. Since this is the first of a three year study, this water and materials budget is preliminary and is subject to change as future information might indicate. There are some areas of the budget which will improve with time and an additional effort is currently underway to increase the overall accuracy of the water and materials budget.

The methods used to calculate the materials budget are explained in Appendix A. The terms utilized in this Section are defined in Appendix D.

Direct drainage and inflows from minor ungauged tributaries were not computed for this study. These unaccounted for residual sources are combined with the error in hydrologic measurement and have been accounted for in the water budget's "other sinks" term.

East Lake Tohopekaliga

The annual water and materials budget (October through September) for East Lake Tohopekaliga is shown in Table 8, with a monthly breakdown depicted in Figure 9. The major source of water which combined represented 89% of the total flow to East Lake Tohopekaliga was shared approximately equally between Boggy Creek, rainfall, and S-62 . However, the flows through S-62 occurred only during the period April through September 1982. The water releases at S-62 and S-59 during this period were necessary to maintain the upstream lake stages and remove the additional water from the basin which was the

TABLE 8. WATER AND MATERIALS BUDGET FOR EAST LAKE TOHOPEKALIGA (10/1/81 - 9/30/82)

	Flow (ac-ft)	% of Total	P Load (10^6 g)	% of Total	N Load (10^6 g)	% of Total	Chloride (10^6 g)	% of Total
Inflows								
Boggy Creek	46,077	28	7.9	49	63.6	24	890.4	35
Rainfall	51,058	32	5.4	34	89.4	33	264.5	10
S-62	46,498	29	1.6	10	82.7	30	1,060.6	42
Seepage	14,726	9	0.8	5	28.7	11	272.7	11
Dakota Ditch	492	1	0.1	1	0.4	1	8.2	1
Jim Branch	2,919	2	0.3	2	5.8	2	46.9	2
Total Inflow	161,770		16.0		270.6		2,543.3	
Outflows								
S-59	92,873	61	3.4		88.9		2,336.1	
Evaporation	59,154	39	-	-	-	-	-	
Total Outflow	152,027		3.4		88.9		2,336.1	

Summary

	Flow (ac-ft)	P Load (10^6 g)	N Load (10^6 g)	Chloride (10^6 g)
Total Inflow (M_{in})	161,770	16.0	270.6	2,543.3
Total Outflow (M_{out})	152,027	3.4	88.9	2,336.1
Change in Storage	25,957	0.6	23.0	710.8
Other Sinks	-16,214	12.0	158.7	-503.6
Error	-16%			-18%
Areal Loading Rate(g/m^2-yr)		0.34	5.78	54.34

Surface area	11,563.5	acres = 4.680×10^7 m^2
Lake Volume	100,350	acre-feet
Residence Time (τ_ω)	1.08	yrs.
Hydraulic Load (q_s)	2.92	m/yr

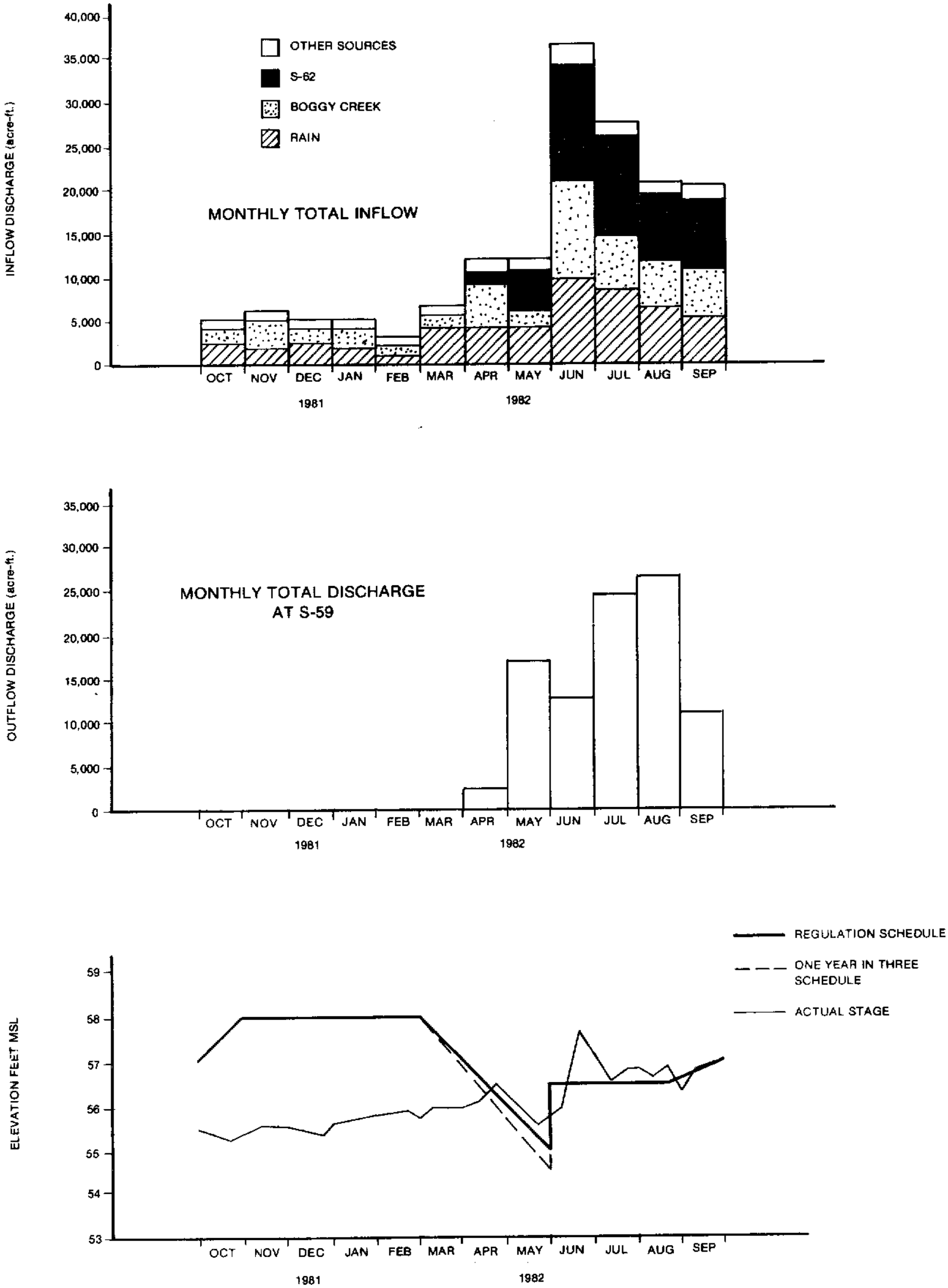


Fig. 9 EAST LAKE TOHOPEKALIGA INFLOW, OUTFLOW AND STAGE

result of increased rainfall activity during this period. Discharges through the St. Cloud Canal at S-59 represented over 60% of the loss of water from East Lake Tohopekaliga. The balance was due to evaporation.

Chloride was also considered in the materials budget as an accuracy check. Since chloride is a conservative ion, the chloride budget should theoretically account for all additions or losses over time, and the error should be about the same as the water budget error. This was the case, with the chloride and water budget errors equaling -18% and -16%, respectively. The negative term, however, indicates that the budgets either underestimated the inflow, or overestimated the outflow terms, or a combination of both. Nevertheless, the overall accuracy of the water budget and, therefore, the materials budget appears good.

Boggy Creek contributed the most phosphorus (49%) while rainfall contributed the most nitrogen (33%). Although S-62 supplied as much water as did Boggy Creek and rainfall, its phosphorus contribution was much smaller.

Table 9 compares the nutrient mass loads and areal loading rates for East Lake Tohopekaliga during this study and other previous studies. The data generally indicates good agreement with the other studies for nitrogen. For the phosphorus mass and areal loadings, the data collected during this study show that the 1981-82 phosphorus load was less than 50% of the previous loads. Based on one year's results, it is too early to tell if this is a developing trend in improved water quality or an impact of the heavy rains in the second half of the study year.

Lake Tohopekaliga

Table 10 presents the annual water and materials budget for Lake Tohopekaliga. Figure 10 shows the seasonal effects of stage and discharge for Lake Tohopekaliga.

TABLE 9. COMPARATIVE MASS LOADINGS AND AREAL LOADING RATES FOR EAST LAKE TOHOPEKALIGA

	Total Nitrogen		Total Phosphorus	
	Mass	Areal	Mass	Areal
Source	(gms X 10^6)	(gms/m^2/yr)	(gms X 10^6)	(gms/m^2/yr)
This study, 1982	271	5.8	16	0.3
Federico and Brezonik, 1975	291	5.9	68	1.4
EPA, 1977	364	7.5	36	0.7

TABLE 10. WATER AND MATERIALS BUDGET FOR LAKE TOHOPEKALIGA (10/1/81-9/30/82)

	Q (ac-ft)	% of Total	TPO_4 (10^6 g)	%of Total	Total N (10^6 g)	% of Total	Chloride (10^6 g)	% of Total
Inflows								
Shingle Creek	170,729	41	95.1	65	341.8	41	5,205.7	58
St. Cloud Canal	93,887	22	12.3	8	117.0	14	2,336.7	26
Mill Slough	15,142	4	3.5	2	25.2	3	199.2	2
Johnson Ditch	1,206	1	0.3	1	8.6	1	42.9	1
S. Partin Ditch	8,522	2	0.9	1	23.5	3	56.9	1
N. Partin Ditch	11,879	3	0.9	1	20.7	2	113.2	1
Judges Dairy	1,169	1	3.3	2	12.2	1	67.8	1
E. Kissimmee Ditch	6,429	2	3.0	2	10.0	1	149.0	2
W. Kissimmee Ditch	2,551	1	14.4	10	55.0	7	122.4	1
Partin Canal	1,827	1	0.7	1	3.8	1	53.9	1
Partin Pump	652	1	0.1	1	4.7	1	28.2	1
Seepage	5,838	1	0.7	1	35.2	4	71.9	1
Rainfall	97,210	23	10.3	7	170.3	20	503.6	6
Total Inflow (M_{in})	417,041		145.5		828.0		8,950.8	
Outflows								
S-61	247,688	72	101.9		867.4		8,428.7	
Evaporation	95,194	28						
Total Outflow (M_{out})	342,882		101.9		867.4		8,428.7	
SUMMARY								
Total Inflow (M_{in})	417,041		145.5		828.0		8,950.8	
Total Outflow (M_{out})	342,882		101.9		867.4		8,428.7	
Change in Storage	11,719		4.4		38.0		317.3	
Other Sinks	62,440		39.2		-77.4		204.8	
Error	49.6%						4.2%	
Areal Loading Rate gms/m^2-yr			1.79		10.2		110.0	

Surface Area 20,113 acres = $8.14 \times 10^7 m^2$
Lake Volume 125,856 acre-feet
Residence Time (τ_ω) 0.51 yrs
Hydraulic Load (q_s) 4.85 m/yr

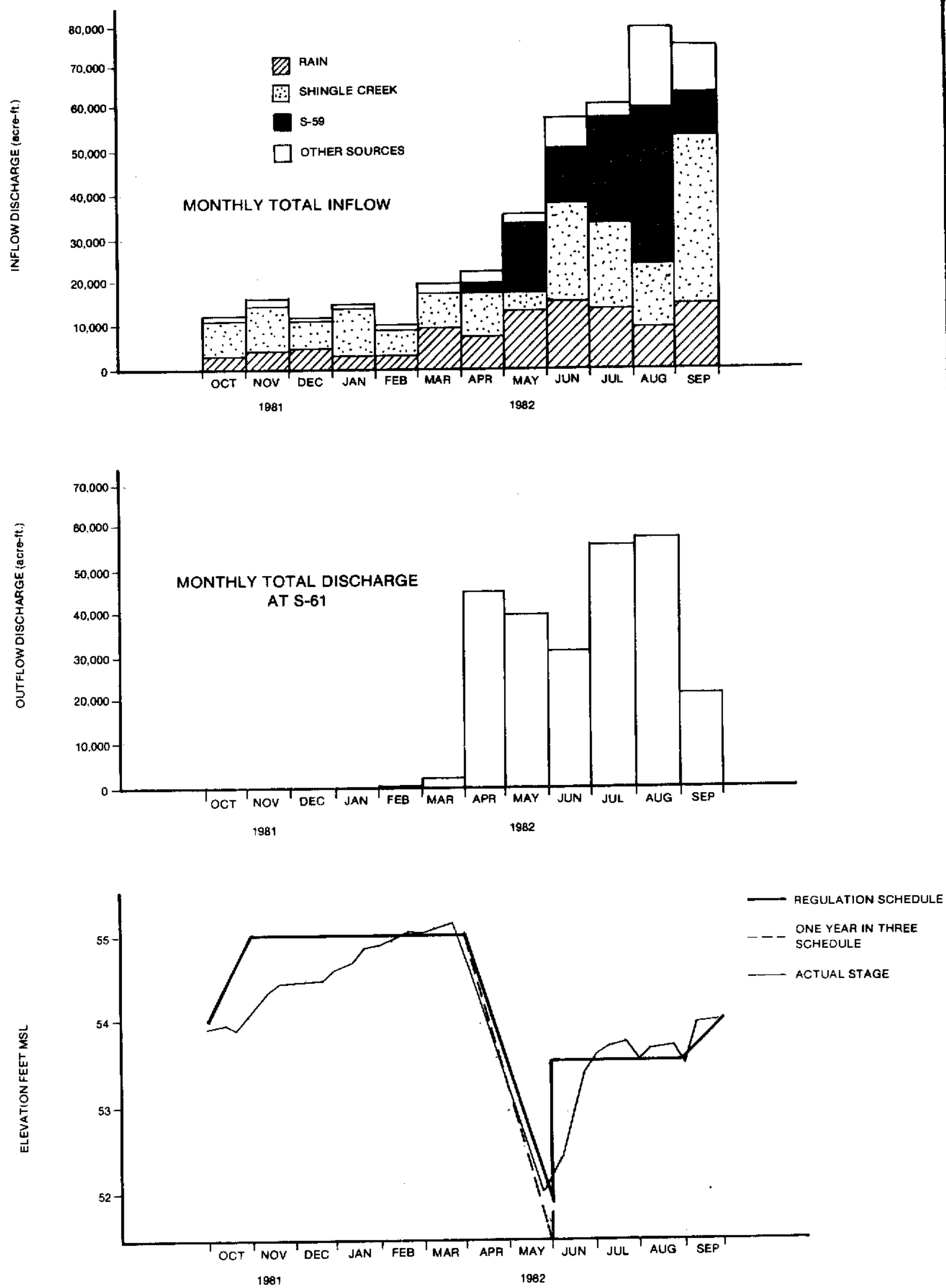


Fig. 10 LAKE TOHOPEKALIGA INFLOW, OUTFLOW AND STAGE

The error in the water budget for Lake Tohopekaliga was calculated to be approximately 50%. As noted earlier, this term represents the combined effects of the unmeasured inflows and the error in measurements for the gauged tributaries. The positive error suggests the water budget is either overestimating the inflows, underestimating the outflows, or a combination of both. The large error in the water budget for Lake Tohopekaliga cannot currently be explained. However, two areas currently being investigated are: (1) the comparatively greater than "normal" inflows from Shingle Creek during this study, and (2) possible underestimation of evaporation rates due to poor evaporation pan data.

The major source of water to Lake Tohopekaliga was Shingle Creek (41%), followed by rainfall (23%), and the St. Cloud Canal discharges at S-59 (22%). Collectively, these made up almost 90% of the total inflow to Lake Tohopekaliga. Discharges through S-61 in Southport represented over 70% of the loss of water from Lake Tohopekaliga. The rest was due to evaporation. Most of the water releases to Lake Tohopekaliga through S-59 and from the lake at S-61 occurred between April and September 1982. These releases were necessary to conform to the regulation schedule. Figure 10 also shows that the contribution of water from "other sources" increased during the summer as a result of increased nonpoint source runoff.

Shingle Creek contributed the most phosphorus (65%) and nitrogen (41%) to Lake Tohopekaliga. Rainfall contributed the second largest amount of nitrogen (20%). The West Kissimmee City Ditch and Judges Dairy both supplied disproportionately great shares of nitrogen and phosphorus to Lake Tohopekaliga as compared to their water inputs. The West Kissimmee City Ditch contributed the second largest amount of phosphorus (10%), while discharging only 1 percent of the water to Lake Tohopekaliga. Although Judges Dairy was shown earlier to have elevated nutrient levels, the importance of this tributary discharge to the whole lake was relatively minor since it represented only 2 and 1 percent of the phosphorus and nitrogen total loads, respectively. Local impacts to the lake due to Judges Dairy and the West Kissimmee City Ditch, however, may be significant since the northern end of the lake is partly isolated from the lake's main body.

Table 11 presents a comparison between the nutrient mass loadings and available areal loading rates for Lake Tohopekaliga during this study and other previous studies. While the nitrogen load (828 X 10^6 g) is comparatively higher during the first year of this study than for most of the previous studies, the areal loading rate (10.2 g/m^2-yr) is similar. The phosphorus load (146 X 10^6 g) and areal loading (1.8 g/m^2-yr) was significantly less than the computed results from previous studies. The lower P loading is due to the reduced load from Shingle Creek as discussed earlier.

Table 12 compares the point and nonpoint source contributions to Lake Tohopekaliga. The point source contribution to Lake Tohopekaliga is comprised of all major wastewater treatment plants located within the lake's watershed. The controllable nonpoint source load is defined as the loading contribution from all other sources to Lake Tohopekaliga except the noncontrollable nonpoint sources (rainfall, seepage, and water control structure S-59). The controllable nonpoint sources were broken down into north (mostly urban) and south (mostly agricultural) by an arbitrary line from elements south of the St. Cloud Canal to just south of the Shingle Creek Basin. The percent contributions for each source was computed as the percentage of the total inflow to Lake Tohopekaliga.

With respect to flow, the controllable nonpoint sources and the noncontrollable nonpoint sources were essentially equal (46% and 47%,

TABLE 11. COMPARATIVE MASS LOADINGS AND AREAL LOADING RATES FOR LAKE TOHOPEKALIGA

Source	Total Nitrogen Mass (gms X 10^6)	Total Nitrogen Areal (gms/m^2/yr)	Total Phosphorus Mass (gms X 10^6)	Total Phosphorus Areal (gms/m^2/yr)
This study, 1982	828	10.2	146	1.8
Federico and Brezonik, 1975	736	9.7	336	4.4
EPA-Atlanta, 1980	768	9.1	194	2.3
EPA-Washington, 1981	753	9.9 1/	194	2.5 1/
ECFRPC, 1978	792	10.4 1/	270	3.5 1/
USEPA, 1977	1,631	21.4	372	4.9

1/ Lake area from Phelps, G.G., 1982, to compute areal loads.

TABLE 12. LAKE TOHOPEKALIGA WATER AND NUTRIENT INPUTS

Source	Water (acre-feet)	%	Phosphorus (gms X 10^6)	%	Nitrogen (gms X 10^6)	%
Point Source: 1/						
Sand Lake Rd. WWTP	9,290		10.2		131.3	
McLeod Rd. WWTP	13,876		28.0		123.3	
Camelot Manor WWTP	344		1.8		3.5	
St. Cloud WWTP	1,014		8.9		28.1	
Kissimmee Interim WWTP	756		0.8		1.8	
Kissimmee Main WWTP	1,751		11.0		55.0	
Subtotal	27,031	6	60.7	42	343.5	41
Controllable NPS:						
North (Shingle Creek	147,219		55.1		83.7	
(Other	25,263		13.1		54.1 2/	
South	21,605		2.1		52.8	
Subtotal	194,087	46	70.3	48	190.6	23
Noncontrollable NPS: 3/						
Subtotal	195,921	47	14.4	10	294.4	36
Total	417,039		145.4		828.5	

1/ FDER, 1982.

2/ The Kissimmee West City Ditch controllable nonpoint source contribution was considered insignificant and, therefore, assumed to be zero.

3/ Noncontrollable NPS includes rainfall, seepage, and S-59 discharge from E. Lake Tohopekaliga.

respectively) and when combined were the major source of water to the lake. Controllable nonpoint sources and point sources accounted for approximately equal contributions of phosphorus (48 and 42%, respectively) to the lakes. Combined they accounted for 90% of the total phosphorus input. Point sources contributed the most nitrogen (41%), followed by the noncontrollable nonpoint sources (36%).

Of the point sources, the three largest contributors of water and nutrients were the Sand Lake Rd WWTP, the McLeod Rd WWTP, and the Kissimmee Main WWTP. The Kissimmee Main WWTP, while contributing 1/5 as much total flow as the Sand Lake Rd WWTP, contributed more phosphorus and slightly less than 1/2 of the nitrogen load contributed by Sand Land Rd WWTP to Lake Tohopekaliga. This demonstrates that although the quantity of water delivered to Lake Tohopekaliga from the Kissimmee main plant is low, the nutrient levels in the effluent water are high enough to cause this plant's loadings to become a significant component of the total point source loading to Lake Tohopekaliga.

LAKE WATER QUALITY

Introduction

In order to establish lakewide water quality in both East Lake Tohopekaliga and Lake Tohopekaliga, some routine sampling sites were omitted from mean computations to prevent areal bias. Specifically, as depicted on the map of East Lake Tohopekaliga (Fig. 2), three of the sample sites (A02, A03, and A04) are equally distributed within the main body of the lake. The remaining fourth station, A01, is centered in Fells Cove. Although the surface area of Fell's Cove represents only 6% of the total surface area of East Lake Tohopekaliga, the water quality data at that site would represent a full 25% of the general water quality if it was included in the arithmetic mean. Since this would introduce an areal bias this station was deleted from the computations, and only quality data at A02, A03, and A04 were used in the calculation of East Lake Tohopekaliga grand means. Similarly, in Lake Tohopekaliga there is a greater density of water quality sites within the northern half of the lake, and although sites B01 and B03 offer valuable information, they were not used in the calculation of grand means.

General water quality for the period of study is shown in Table 13. Individual values represent the average of 12 monthly readings. Stations A01, B01, and B03 are also included for comparative purposes.

Lakewide Characteristics

East Tohopekaliga

Generally, the water quality in the main body of East Lake Tohopekaliga was relatively good. The pH levels were slightly acidic averaging 6.4, but occasionally measured at levels as low as 5.4. This was due to low pH inflows and the very low alkalinity of East Lake Tohopekaliga. Specifically, the

TABLE 13. COMPARISON OF EAST LAKE TOHOPEKALIGA AND LAKE TOHOPEKALIGA AVERAGE WATER QUALITY (10/1/81 - 9/30/82)

Parameter[1/]	East Lake Tohopekaliga [2/]	A01	Lake Tohopekaliga [3/]	B01 & B03
pH (units)	6.5	5.8	8.2	7.5
Temp (^{o}C)	22.7	22.7	23.7	23.3
D.O.	8.3	8.1	9.0	7.9
Cond. (micromhos/cm)	145.	150.	269.	268.
Secchi (meters)	2.07	0.72	0.55	0.64
Turb. (NTU)	1.7	4.6	7.6	3.4
Color (PTU)	31.	119.	78.	148.
TOC	7.4	12.3	20.2	21.7
TSS	3.8	5.3	11.5	3.3
NO_2	0.004	0.005	0.005	0.015
NO_3	0.004	0.015	0.018	0.095
NH_4	0.02	0.02	0.01	0.03
Organic N	0.69	1.02	2.15	1.70
Total N	0.72	1.05	2.33	1.83
OPO_4	0.004	0.004	0.149	0.447
TPO_4	0.020	0.028	0.303	0.549
Na	13.27	12.20	23.13	21.54
K	1.95	1.44	3.11	3.51
Ca	2.73	4.95	14.62	18.37
Mg	3.23	3.00	4.61	4.48
SO_4	15.4	20.3	19.0	18.5
Cl	22.2	20.8	31.0	26.7
SiO_2	0.8	1.6	1.7	3.1
Alk. (mg/L as $CaCO_3$)	8.00	6.00	43.00	44.5
Hard. (mg/L as $CaCO_3$)	19.0	24.7	55.4	64.3
Chlor *a* (mg/m^3)	5.3	6.0	68.3	29.5
Total Fe	0.14	0.46	0.25	0.26

1/ units in mg/L unless otherwise indicated.

2/ average of stations A-2 - A04

3/ average of stations B02 and B04-B09.

alkalinity of East Lake Tohopekaliga averaged 8.00 mg/L as $CaCO_3$, but individual readings below the limits of detection (5.00 mg/L as $CaCO_3$) were common.

Daytime dissolved oxygen levels were relatively high, averaging 8.3 mg/L, with no observations below the Chapter 17-3 State Standard of 5.0 mg/L.

East Lake Tohopekaliga had low levels of chlorophyll a, an indicator of algal biomass. Chlorophyll a concentrations in East Lake Tohopekaliga rarely exceeded 10.0 mg/m^3, much lower than any of the other four lakes in this study.

Specific conductance measured in East Lake Tohopekaliga was moderate (145 micromhos/cm). The major cation was sodium (13.27 mg/L) and the major anions were chloride (22.2 mg/L) and sulfate (15.4 mg/L).

Physical measurements included low color (31 Pt units), low turbidity (1.7 NTU), and low total suspended solids (3.8 mg/L). The mean Secchi depth of 2.07 meters was not representative since on several occasions the Secchi disc was on the bottom of East Lake Tohopekaliga.

Total nitrogen concentrations measured in East Lake Tohopekaliga were low, seldom exceeding 1.0 mg/L. The total nitrogen grand mean for the main body of East Lake Tohopekaliga was 0.72 mg/L. Ninety-six percent of the total nitrogen was in the organic form (0.69 mg/L). Levels of NO_2, NO_3, and NH_4 were often below their detection limits.

The average total phosphorus level in East Lake Tohopekaliga was moderately low (0.020 mg/L) with the orthophosphate fraction consistently recorded below the limits of analytical detection (0.004 mg/L) at all four East Tohopekaliga stations.

Other parameters recorded for the main body of East Lake Tohopekaliga were total organic carbon (7.4 mg/L), SiO_2 (0.8 mg/L), and total iron (0.14 mg/L).

Lake Tohopekaliga

In general, pH values in Lake Tohopekaliga were on the alkaline side characterized by a grand mean of 8.2. Although many of the inflows to this lake are acidic in nature, the mean alkalinity is high enough (0.86 meq/L) to buffer the inflows and result in an slightly alkaline aquatic environment.

Like East Lake Tohopekaliga, surface dissolved oxygen levels in Lake Tohopekaliga were high, averaging 9.0 mg/L, with no observations falling below the 5.0 mg/L State Standard. These dissolved oxygen concentrations were all measured at the surface during daylight hours and are most probably attributed to the high photosynthetic activity as indicated by the high chlorophyll _a_ levels (grand mean - 68 mg/m^3).

Specific conductance demonstrated substantially higher levels in Lake Tohopekaliga than in East Lake Tohopekaliga due largely to high specific conductance inflows. Average specific conductance for the entire lake was 269 micromhos/cm for the period of study, 85% greater than the East Lake Tohopekaliga grand mean. Consequently, ion concentrations displayed substantially higher levels in Lake Tohopekaliga. Calcium displayed the most apparent difference with a five-fold increase in grand mean concentrations from East Lake Tohopekaliga (2.73 mg/L) to Lake Tohopekaliga (14.62 mg/L). Additionally, Lake Tohopekaliga grand means for sodium (23.13 mg/L), potassium (3.11 mg/L), magnesium (4.61 mg/L), sulfates (19.0 mg/L), and chlorides (31.0 mg/L) also demonstrate elevated levels over respective East Lake Tohopekaliga concentrations.

Lake Tohopekaliga also exhibited higher levels of color (78 Pt units), turbidity (7.6 NTU), chlorophyll a (68.3 mg/C/m^3), and total suspended solids (11.5 mg/L), resulting in a secchi grand mean of 0.55 meters which is a quarter of that of East Lake Tohopekaliga.

As in East Lake Tohopekaliga, the concentration of inorganic nitrogen in Lake Tohopekaliga was very low averaging 0.03 mg/L for the period of study. Nitrate (0.018 mg/L) and nitrite (0.005 mg/L) did display levels greater than detection, but the grand means remained low. Total nitrogen (2.33 mg/L), however, was higher due to the moderate concentrations of organic nitrogen (2.31 mg/L) found in the lake. Average ortho and total phosphorus values in Lake Tohopekaliga demonstrated substantial increases over East Lake Tohopekaliga, by ortho and total phosphorus grand means of 0.149 mg/L and 0.303 mg/L, respectively. These values indicate an almost even split between the organic and inorganic constituents of phosphorus on a whole lake basis.

Total iron and silicates were also monitored during this study, yielding grand means of 0.25 mg/L and 1.7 mg/L, respectively, for Lake Tohopekaliga.

Seasonal Analysis

General

Any analysis of seasonal trends within a data set must take two aspects of seasonality into consideration, (1) changes in water quality caused by seasonal changes in the temperature and photoperiod, and (2) shifts in water chemistry in response to hydrological conditions. The first situation is obvious - some water chemistry indices such as productivity or dissolved oxygen are directly influenced by water temperature and the length of daily photoperiod. The second situation, shifts in water chemistry in response to hydrological conditions, is especially pronounced in south Florida where three-quarters of the total annual rainfall falls during the wet season, May 1 to October 31. Associated with rainfall amounts are respective changes in stage levels and quantities of tributary discharge. The changes may occur abruptly in response to stormwater events or more gradually in order to meet regulation schedules. These influences can substantially shift water chemistry parameters and cause apparent seasonal trends.

East Lake Tohopekaliga:

Chlorophyll a data indicated increased levels during the summer months (Fig. 11a). Conversely, dissolved oxygen levels were generally lower in the summer reflecting the lower solubility of oxygen in warmer water. Paralleling the increase in chlorophyll a is an increase in color (Fig. 11b) during the summer months due to the sharp increase in surface inflows to East Lake Tohopekaliga during June-August 1982 (see Part 3). Together, these higher chlorophyll a and color levels produce a decreased secchi depth during the summer months.

Although total phosphorus and total nitrogen levels do display fluctuations during the period of study, there is no clear seasonal pattern

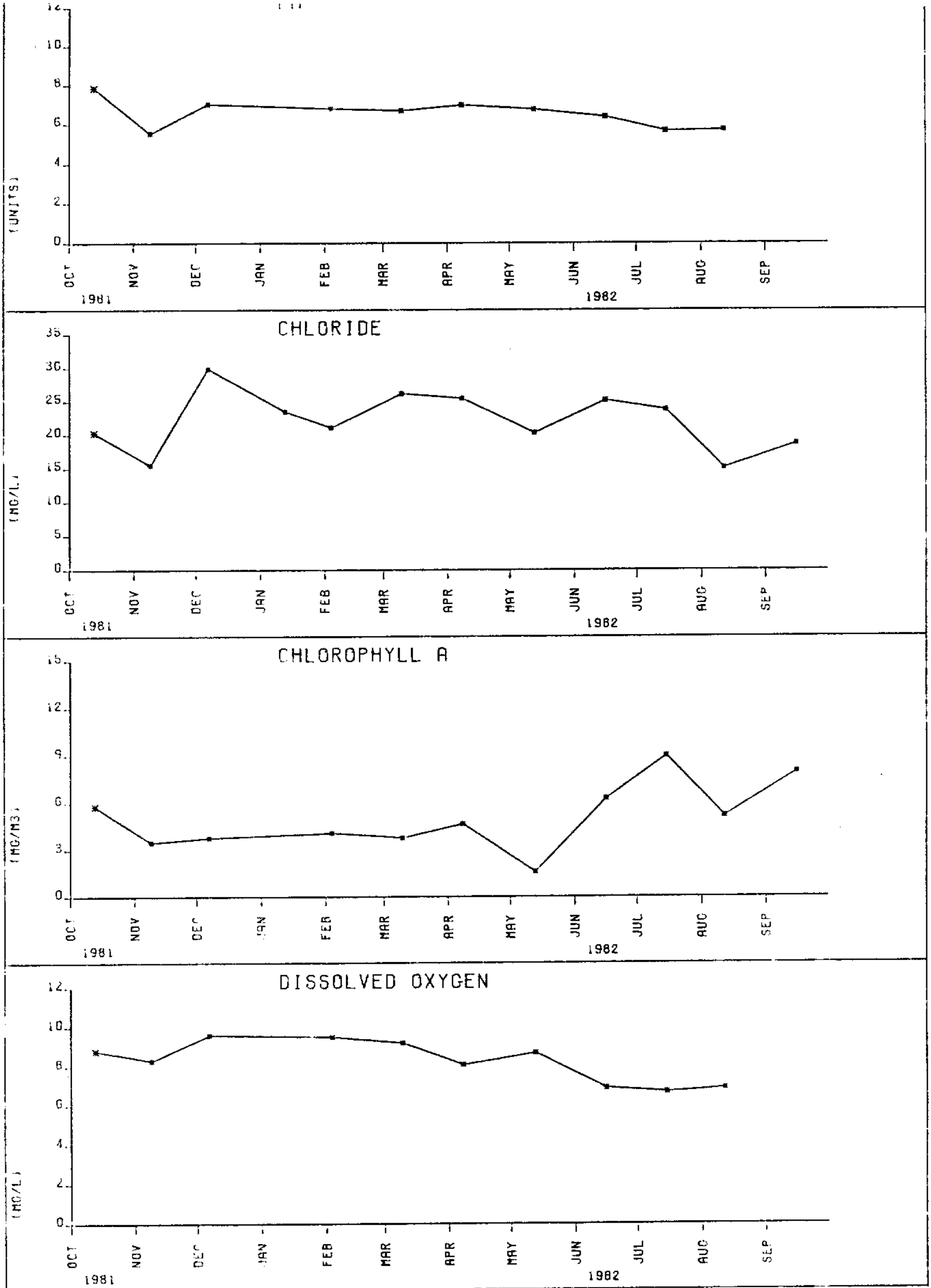


Fig. 11a. Mean Water Quality for East Lake Tohopekaliga 10/81 - 9/82

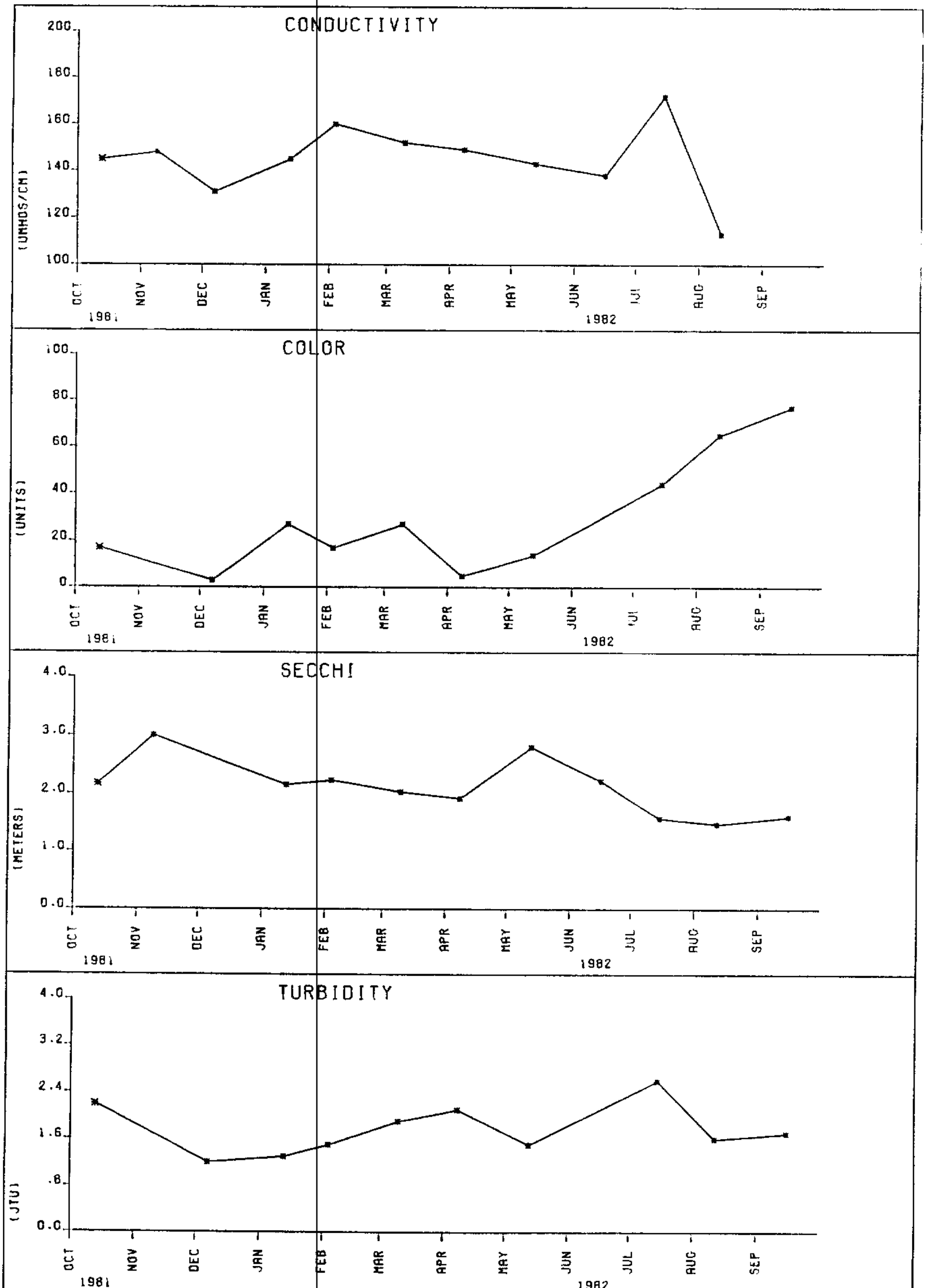


Fig. 11b. Mean Water Quality for East Lake Tohopekaliga 10/81 - 9/82

evident in East Lake Tohopekaliga. Additionally, since both inorganic nitrogen and ortho phosphorus rarely exceed minimum detection limits, no trends could be discerned. Figure 11c also depicts the seasonal graphs for specific conductivity which, aside from a slight increase, in August remained relatively constant during the year.

Lake Tohopekaliga

Many of the seasonal observations made for East Lake Tohopekaliga were less evident in Lake Tohopekaliga. Average chlorophyll a levels are higher but show no discernable seasonal trends during the study year either at individual stations or whole lake averages. For example, the months with the three highest mean chlorophyll a levels are June, October, and February. Dissolved oxygen levels do demonstrate slightly elevated levels during the winter months (Fig. 12a).

Color, turbidity, and secchi disc readings display no clear seasonal trend, with high levels occurring randomly during the year (Fig. 12b).

Like East Lake Tohopekaliga, the components of inorganic nitrogen (nitrites, nitrates, and ammonia) are too low to note any evidence of seasonality. Organic and total nitrogen concentrations did vary substantially in Lake Tohopekaliga during the study year; however, no distinct patterns were evident (Fig. 12c). Several parameters such as chloride, total nitrogen, total phosphorus, and specific conductance demonstrate a decline during the end of this study period. Whether this is a seasonal phenomenon due to greatly increased flow or an indication of a long term improvement in overall lake quality is speculative at this point.

Areal Variations in Water Quality

One of the tools which can be used to graphically assess areal distribution of water quality within a body of water is SYMAP(R) - a computer

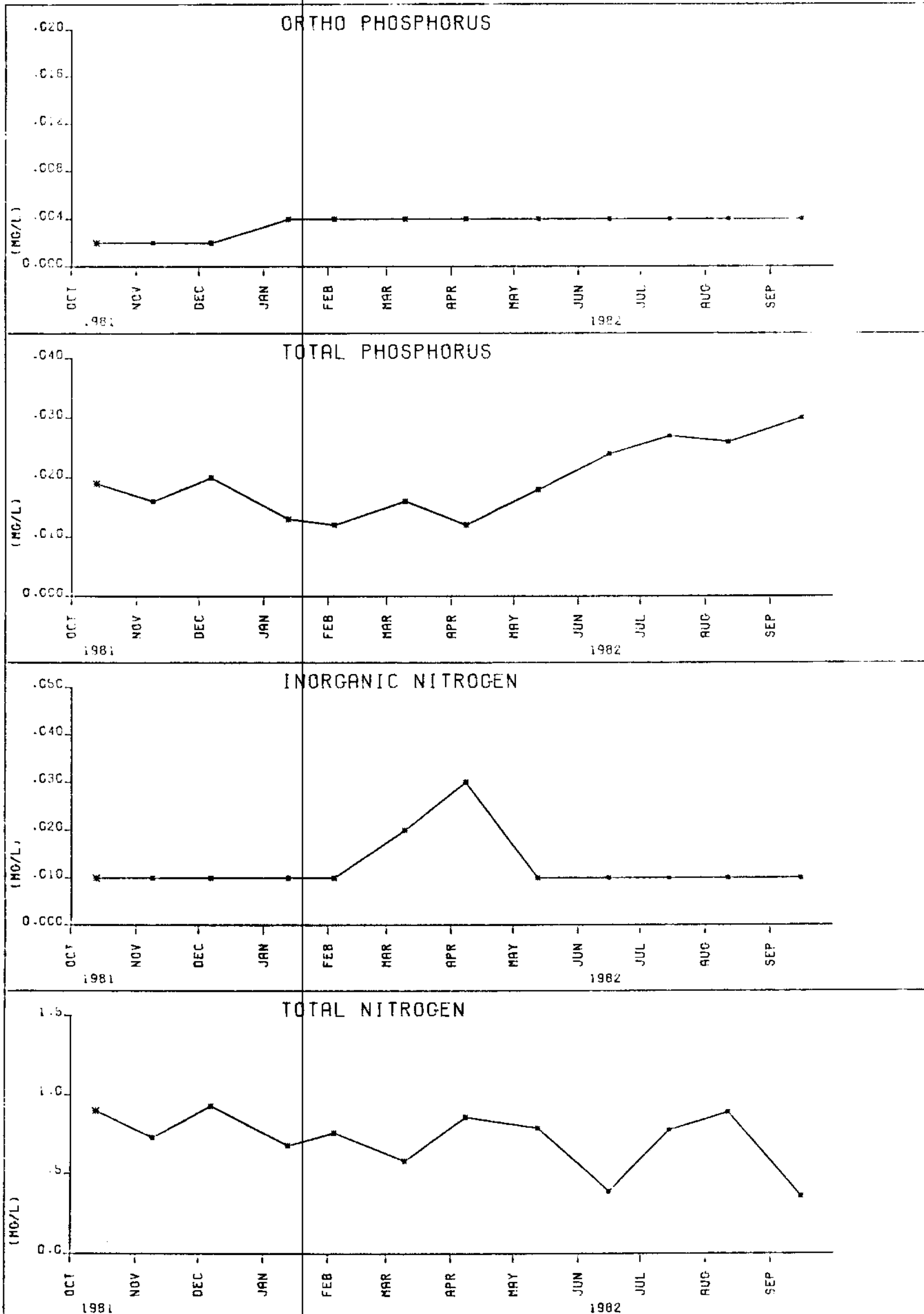


Fig. 11c. Mean Water Quality for East Lake Tohopekaliga 10/81 - 9/82

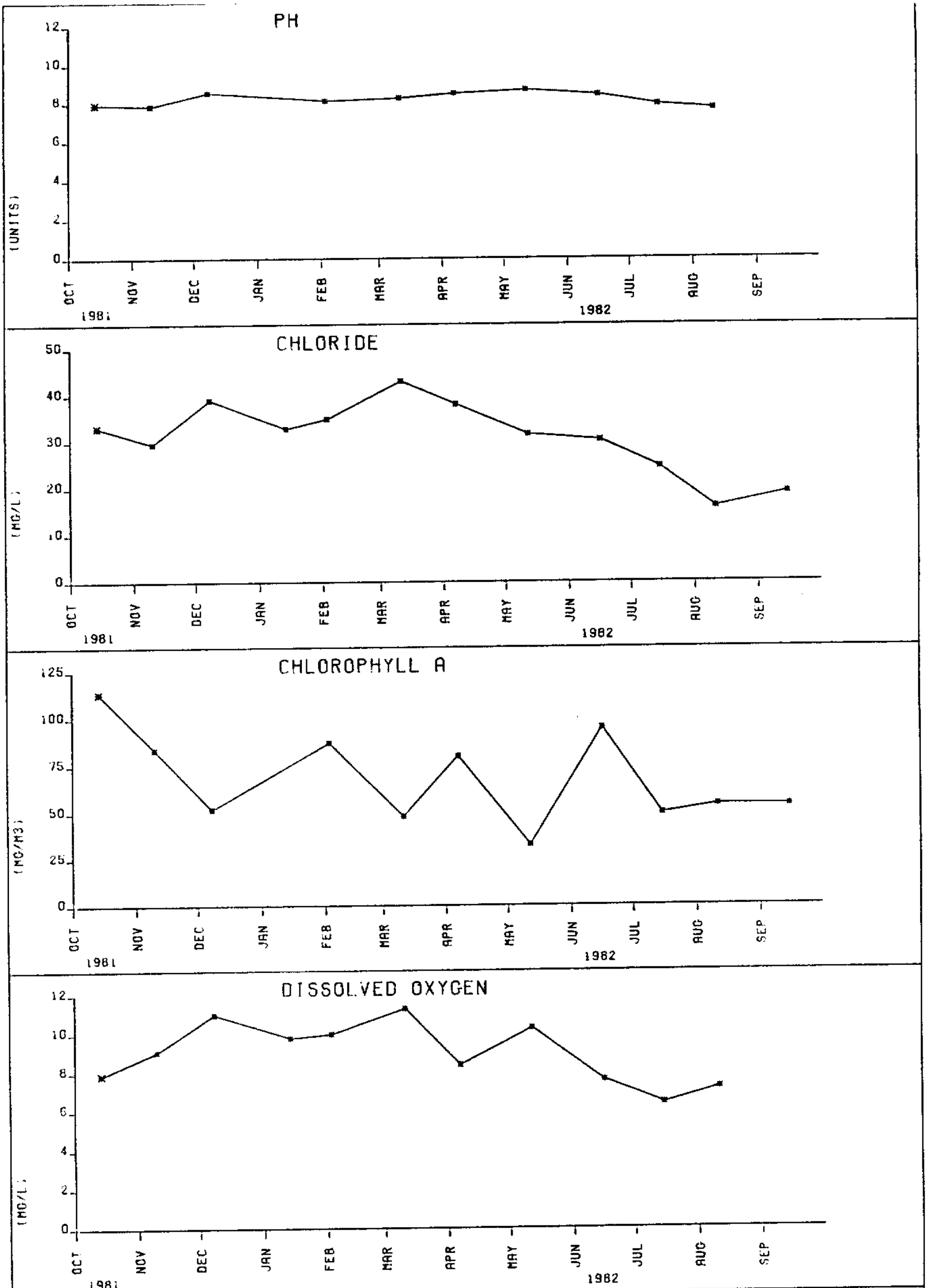


Fig. 12a. Mean Water Quality for Lake Tohopekaliga 10/81 - 9/82

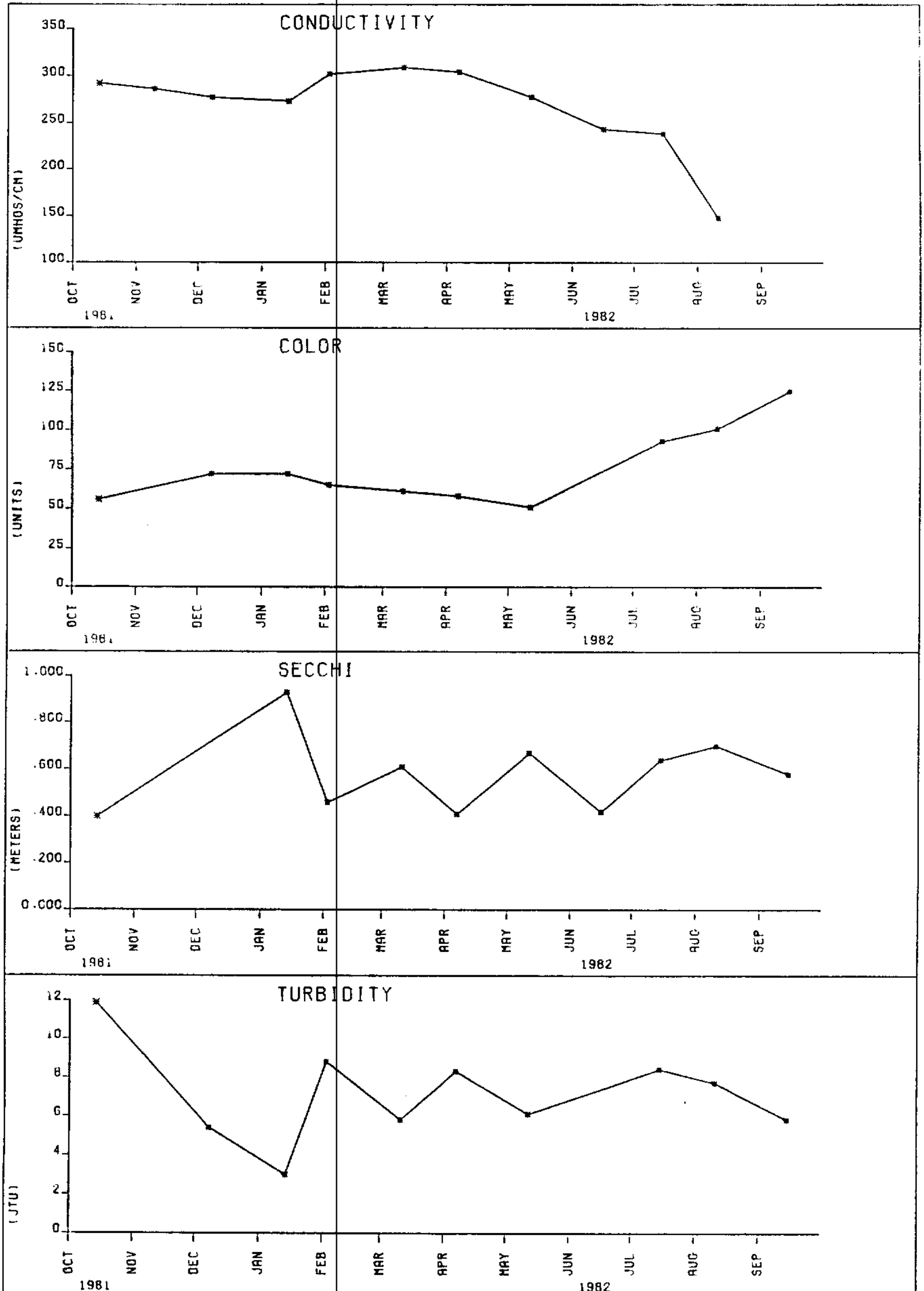


Fig. 12b. Mean Water Quality for Lake Tohopekaliga 10/81 - 9/82

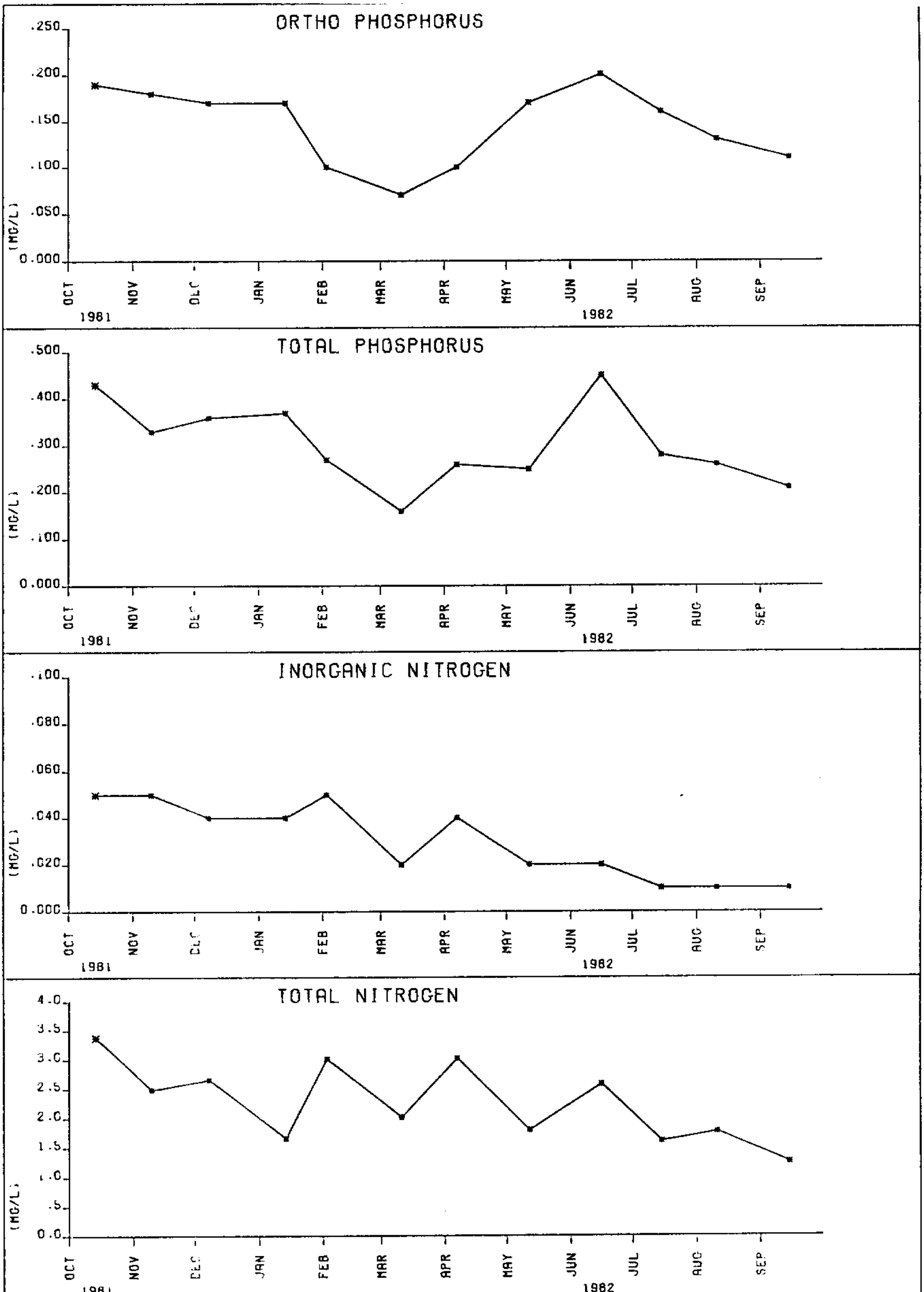


Fig. 12c. Mean Water Quality for Lake Tohopekaliga 10/81 - 9/82

mapping program developed by the Harvard Laboratory for Computer Graphics and Spatial Analysis. The SYMAP package converts individual sample site data into concentration gradients or isopleths to spatially illustrate both similarities and differences in parameter values. The actual sample sites are designated by exact values. For each print location (symbol), the program employs a search radius such that an average of seven data points are included in the interpolation. In turn, the interpolation is distance weighted with the data point values received by the print location being inversely proportional to the square of their distance apart. The technique is similar to that used to construct topographical ground elevation, isothermal, and population density maps. Aside from actual parameter values, there are a number of manipulative factors which can affect the resultant map; the quantity and location of sample sites, the system's physical boundaries and barriers, the selection of contour intervals, etc.

East Lake Tohopekaliga

Three of the four water quality sampling sites located in East Lake Tohopekaliga (A02, A03, and A04) are relatively uniform for most water quality indices. The fourth station (A01), located in the center of Fells Cove, is impacted from inflows from Jim Branch and Lakes Ajay and Hart, as well as being influenced by local septic tanks. These inflows tend to be relatively nutrient enriched, high in color and low in pH compared to the main body of East Lake Tohopekaliga.

Figs. 13 through 17 provide some of the maps of the areal distribution of mean water chemistry estimates for the study period. All maps show the same trend - general homogeneity of the main lake with slightly elevated levels in Fells Cove.

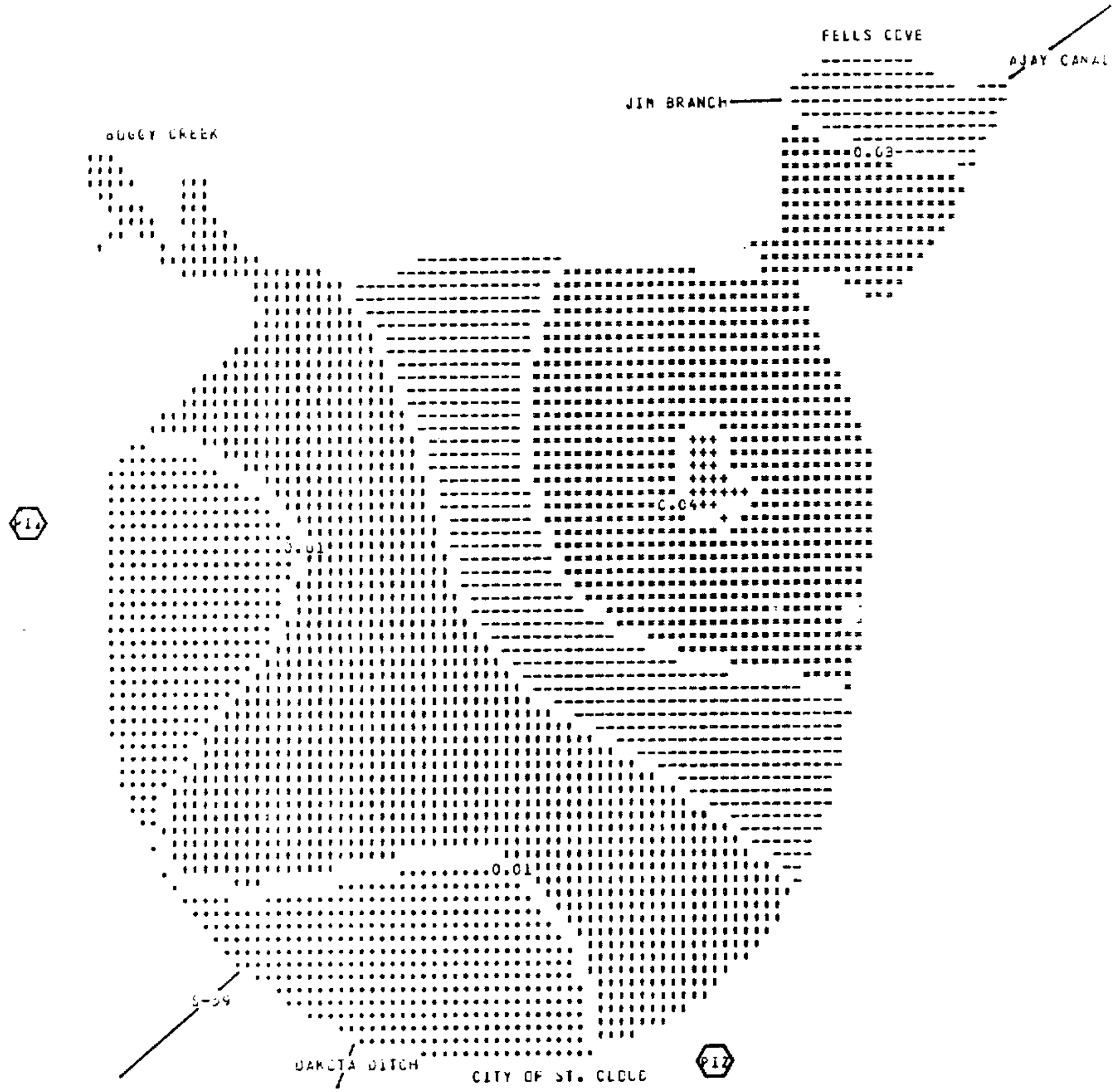


Fig. 13. Areal Distribution of INORGANIC NITROGEN within East Lake Tohopekaliga

0 .5 1.0
SCALE IN MILES

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

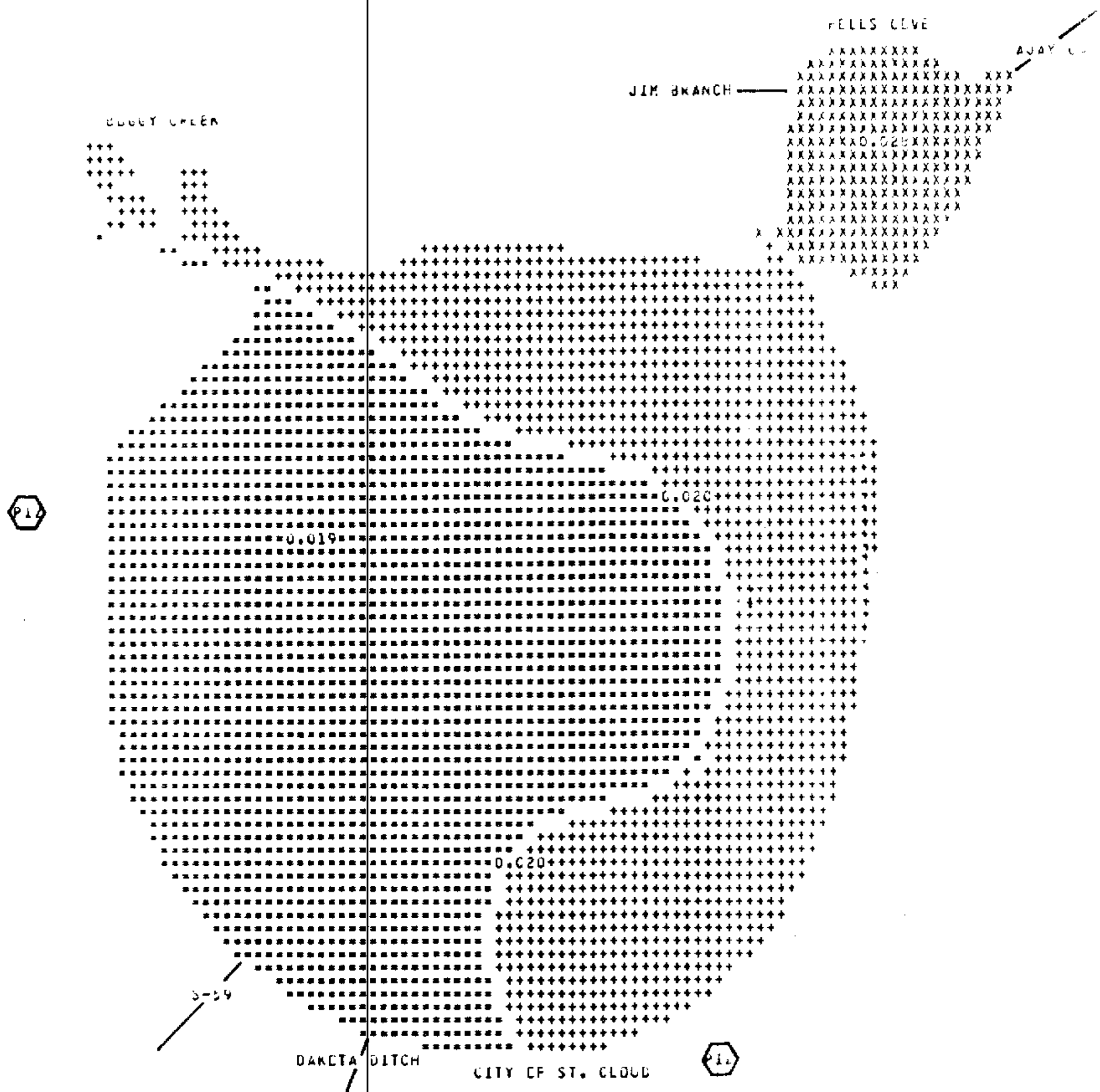
MINIMUM	0.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
MAXIMUM	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	@@@@8@@@@	&&&&9&&&&	████0████
FREQ.	0	2	0	1	1	0	0	0		0



0 .5 1.0
SCALE IN MILES

Fig. 14. Areal Distribution of TOTAL PHOSPHORUS within East Lake Tohopekaliga

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.00	.01	.01	.02	.02	.03	.03	.04	.04	.05
MAXIMUM	.01	.01	.02	.02	.03	.03	.04	.04	.05	.05

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
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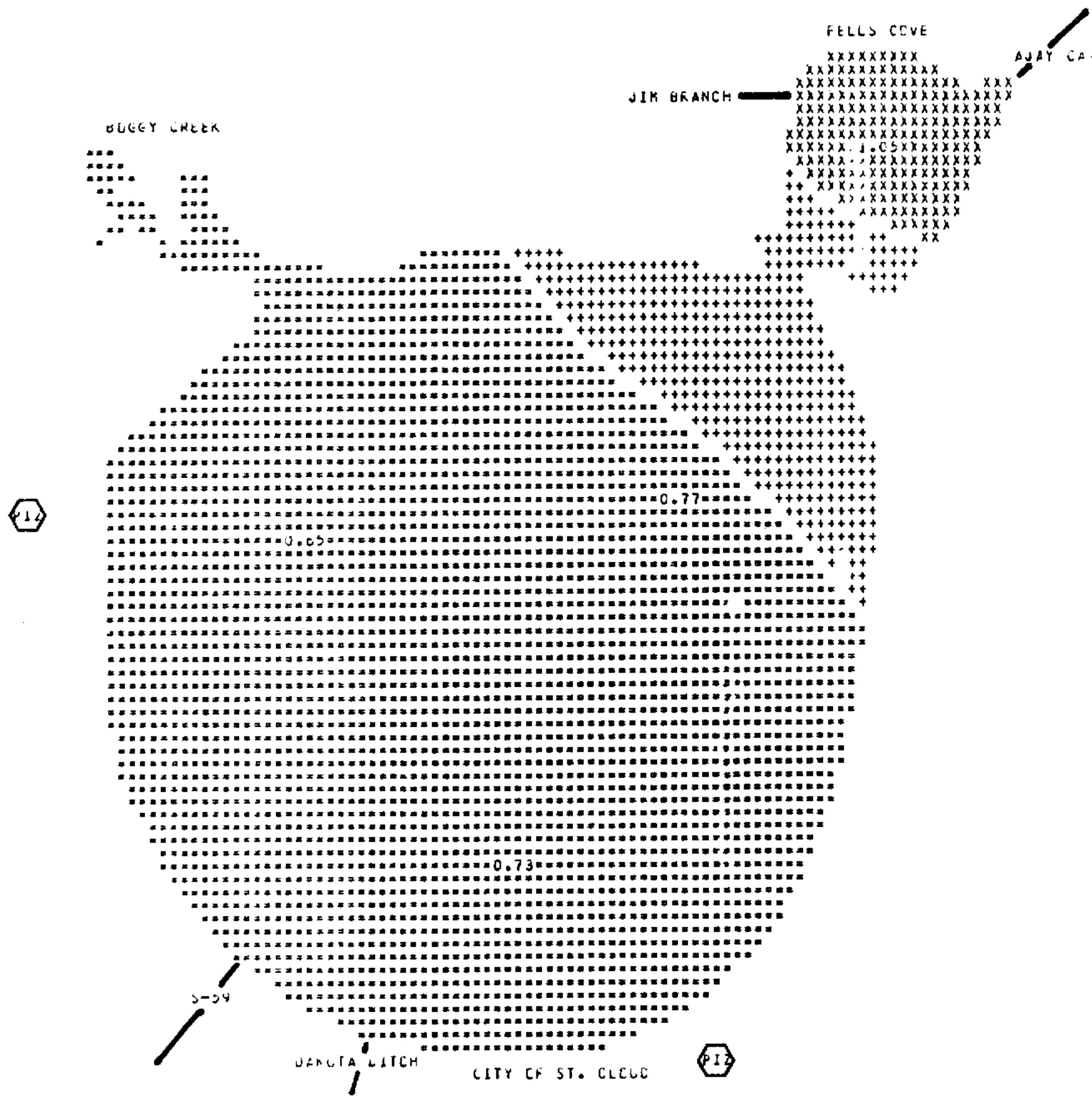


0 .5 1.0
SCALE IN MILES

Fig. 15. Areal Distribution of TOTAL NITROGEN within East Lake Tohopekaliga

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.00	.20	.40	.60	.80	1.00	1.20	1.40	1.60	[illegible]
MAXIMUM	.20	.40	.60	.80	1.00	1.20	1.40	1.60	1.80	[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	[illegible]

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
FREQ.	0	0	0	3	0	1	0	0	0	0

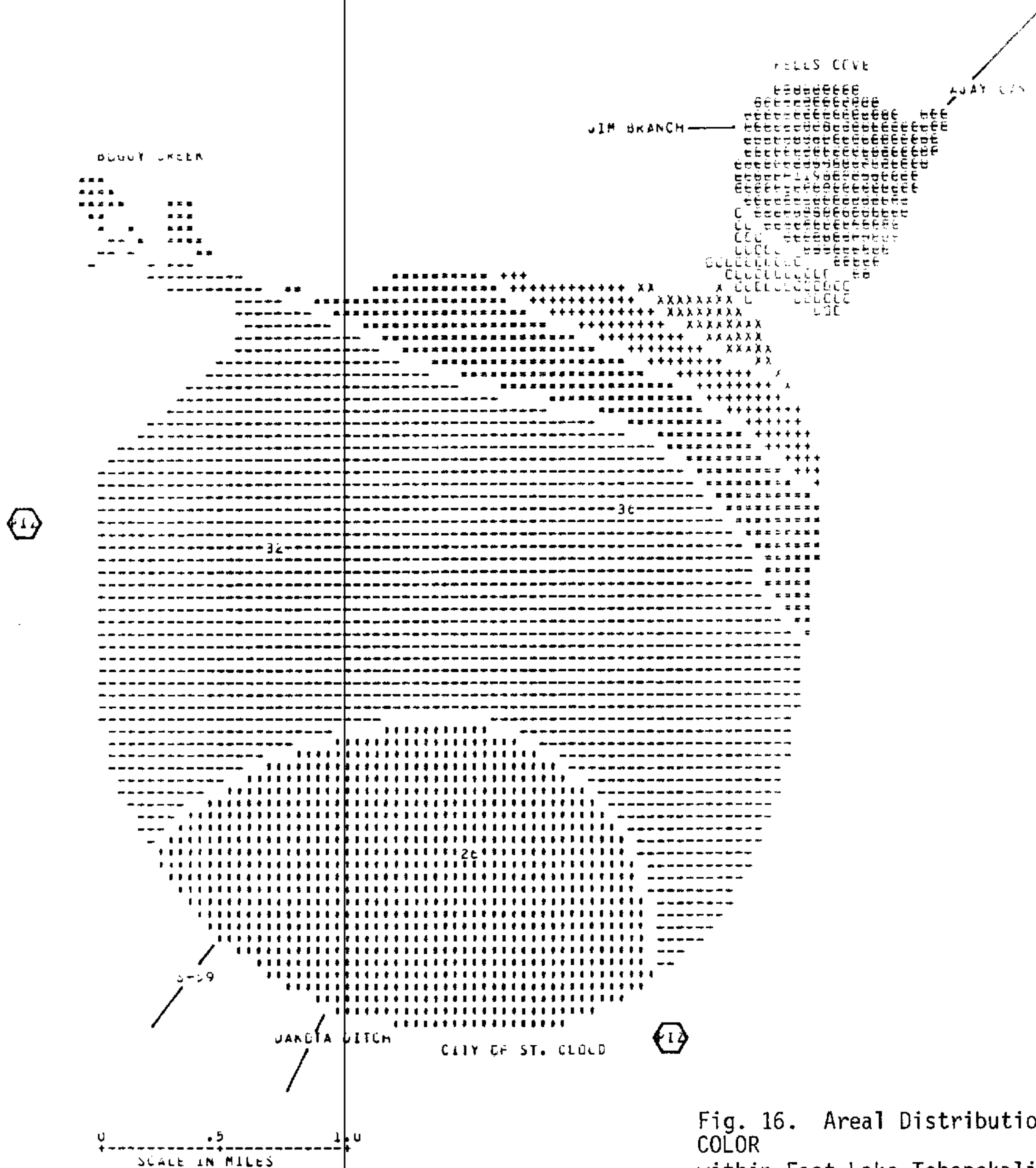


Fig. 16. Areal Distribution of COLOR within East Lake Tohopekaliga

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
(*MAXIMUM* INCLUDED IN HIGHEST LEVEL ONLY)

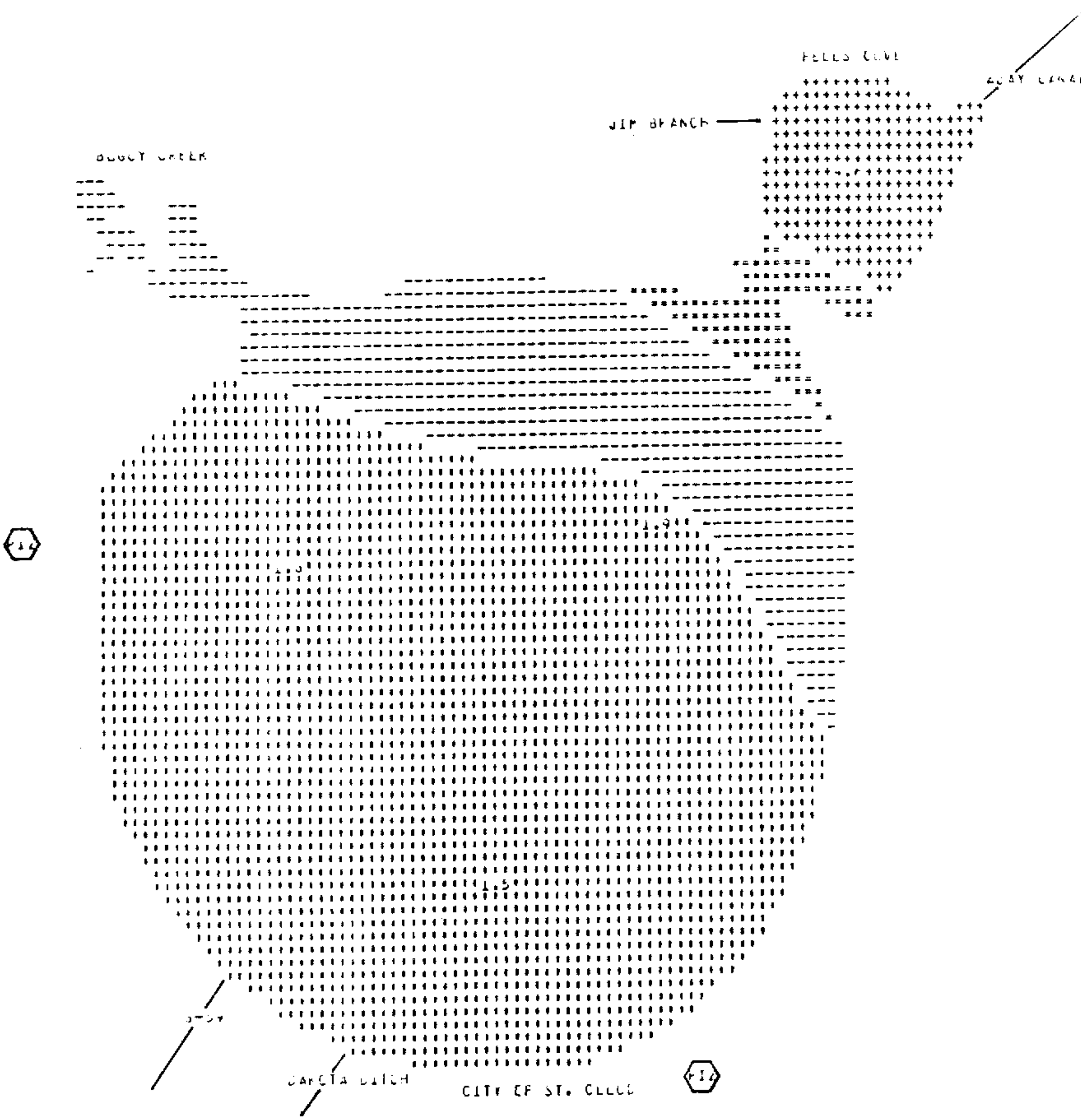
MINIMUM	0.00	15.00	30.00	45.00	60.00	75.00	90.00	105.00	120.00	[illegible]
MAXIMUM	15.00	30.00	45.00	60.00	75.00	90.00	105.00	120.00	135.00	[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	[illegible]

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	....1....	''''2''''	----3----	====4====	++++5++++	XXXX6XXXX	OOOO7OOOO	ØØØØ8ØØØØ	&&&&9&&&&	[illegible]



0 .5 1.0
SCALE IN MILES

Fig. 17. Areal Distribution of TURBIDITY within East Lake Tohopekaliga

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL
('MAXIMUM' INCLUDED IN HIGHEST LEVEL ONLY)

MINIMUM	0.00	1.00	2.00	3.00	4.00	5.00	6.00	7.00	[illegible]	9.00
MAXIMUM	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	[illegible]	10.0[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	[illegible]	[illegible]

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

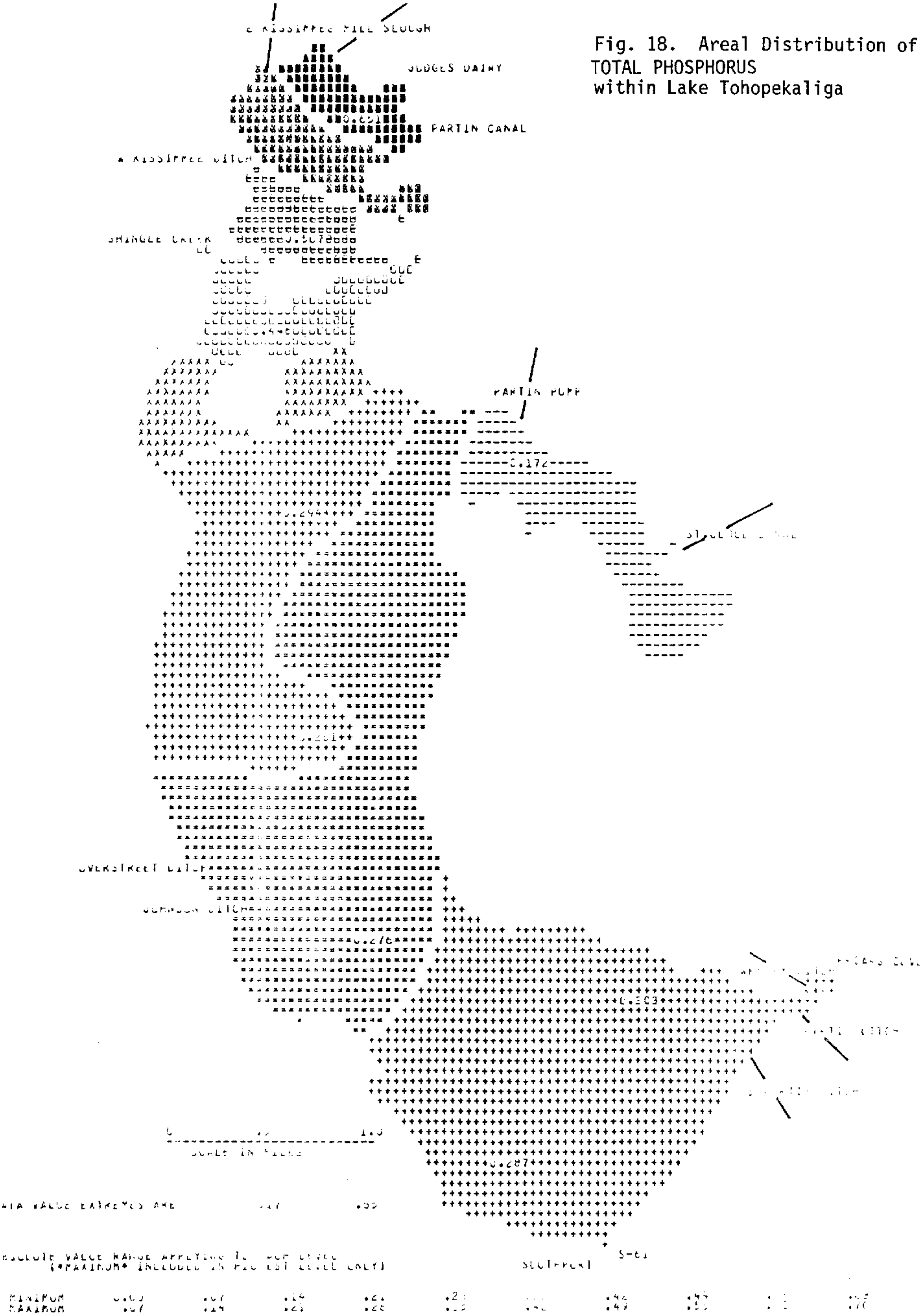
LEVEL	1	2	3	4	5	6	7	8	9	10
SYMBOLS	1	2	3	4	5	6	7	[illegible]	[illegible]	[illegible]

The water quality within Fells Cove is similar to the rest of the lake with respect to nitrite (0.005 mg/L), ammonia (0.02 mg/L), orthophosphorus (0.004 mg/L), dissolved oxygen (8.1 mg/L), specific conductance (145 micromhos/cm), chloride (22.2 mg/L), and most of the major ions. Total nitrogen (1.05 mg/L), nitrate (0.015 mg/L), and phosphorus (0.028 mg/L), however, are significantly elevated above the rest of the lake based on analyses of variance. Other parameters such as turbidity (4.6 NTU) and color (119 Pt Units) also are significantly higher than the rest of the lake, resulting in decreased secchi disc readings (0.72 meters). Additionally, both pH (5.79) and alkalinity (0.12 meq/L) are lower than in the main body of the lake.

Lake Tohopekaliga

The surface inflows to Lake Toho are unequally distributed around the lake. Approximately 90% of the water, 82% of the phosphorus, and 54% of the nitrogen from surface sources enter in the northern 15% of the lake above station B03. This lack of a uniform areal distribution of inflows, coupled with a southerly flow in the lake, establishes conditions for distinct and sometimes dramatic areal distributions of inlake water quality parameters. Since there are no major surface inputs of total nitrogen and phosphorus south of station B03, the expected areal pattern would be for a decreasing trend from north to south as high input loads from the north are flushed and diluted into the remaining 75% of the lake. This areal pattern of decreasing concentrations from north to south was measured for total phosphorus. The average total phosphorus concentrations decreased substantially from 0.651 mg/L at B01 to 0.287 mg/L at B09 (Fig. 18). However, the expected trend was reversed for total nitrogen, which increased the more southerly the direction (1.90 mg/L at B01 to 3.01 mg/L at B08) (Fig. 19). Since only 21% of the

Fig. 18. Areal Distribution of
TOTAL PHOSPHORUS
within Lake Tohopekaliga



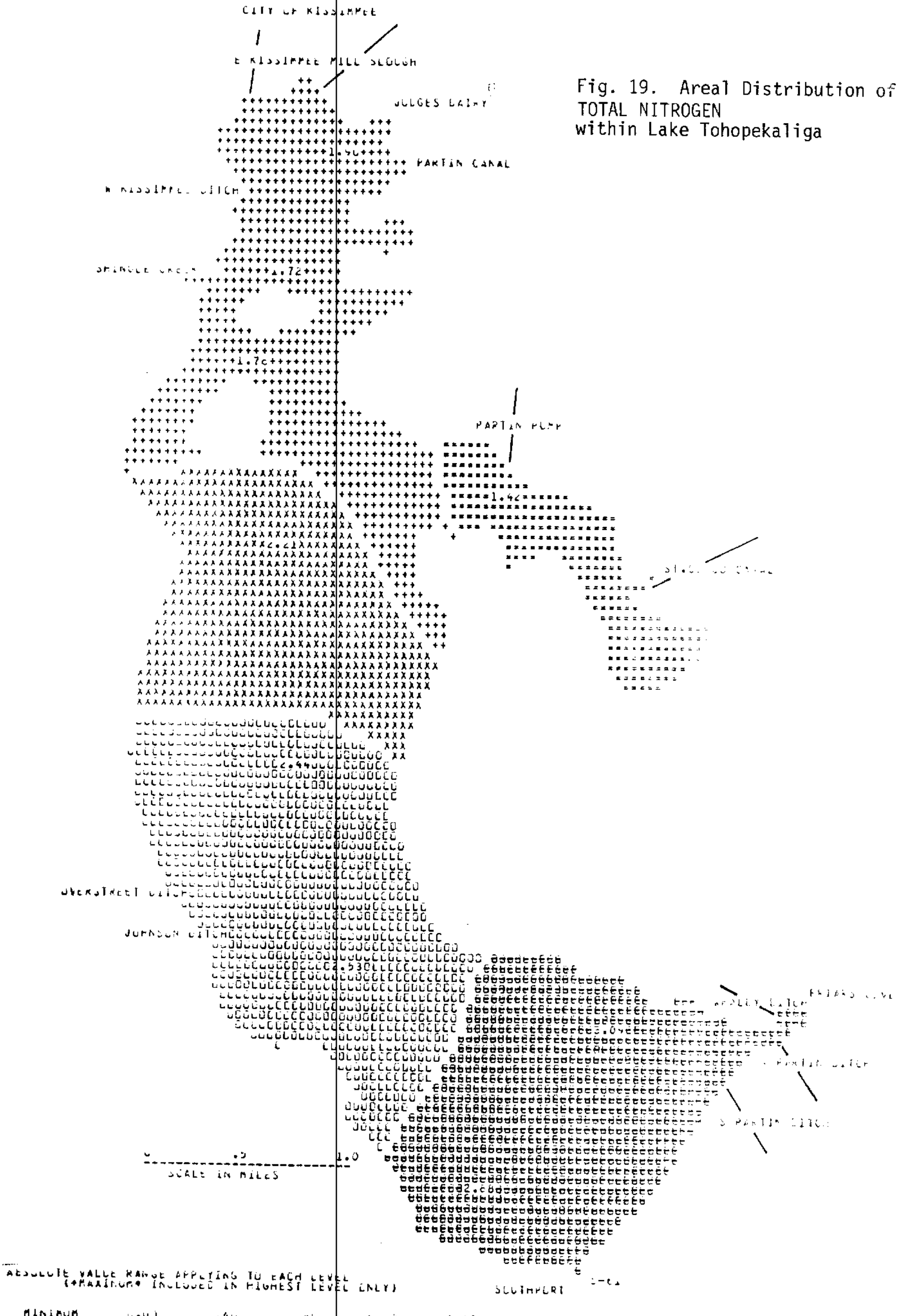


Fig. 19. Areal Distribution of TOTAL NITROGEN within Lake Tohopekaliga

surface inputs of total nitrogen enters the lake south of B03 (with a flow-weighted concentration of 1.22 mg/L), this approximately 1 mg/L (60%) increase cannot be attributed to surface inflows. Therefore, internal loadings are indicated as playing a major role in influencing the total nitrogen concentration in the lake. Since total phosphorus concentration decreased in a southerly direction, the internal loading mechanism appears to influence only the total nitrogen concentrations. Atmospheric nitrogen fixation is one mechanism which would increase total nitrogen concentrations without increasing total phosphorus levels. It is highly probable that large quantities of atmospheric nitrogen are being fixed and incorporated into the lake biomass. In order for such large quantities of nitrogen to be fixed, there must be a large algal population. The chlorophyll a measurements indicate that there is probably sufficient algal biomass present to account for large fixation rates, with a lakewide chlorophyll a annual average of 68 mg/m^3 and discrete chlorophyll a concentrations routinely measure above 100 mg/m^3 in the southern half of the lake. In addition, phytoplankton identification has indicated that nitrogen fixing blue-greens are a dominant algae in the lake. (A more detailed discussion of phytoplankton identification is presented in Part 3, Section 6.) Average chlorophyll a concentrations also parallel the increases in total nitrogen from north (27.9 mg/m^3 at B01) to south (109.6 mg/m^3 at B08) (Fig. 20). This trend is supported by a strong lakewide statistical correlation between total nitrogen and chlorophyll a ($r = 0.82$).

The rapid increase in chlorophyll a from north to south resulted in a rapid assimilation of inorganic nitrogen and phosphorus. Inorganic nitrogen decreased from an average of 0.16 mg/L at B01 to 0.01 mg/L at B09 (Fig. 21). In addition, many of the inorganic nitrogen values measured south of station

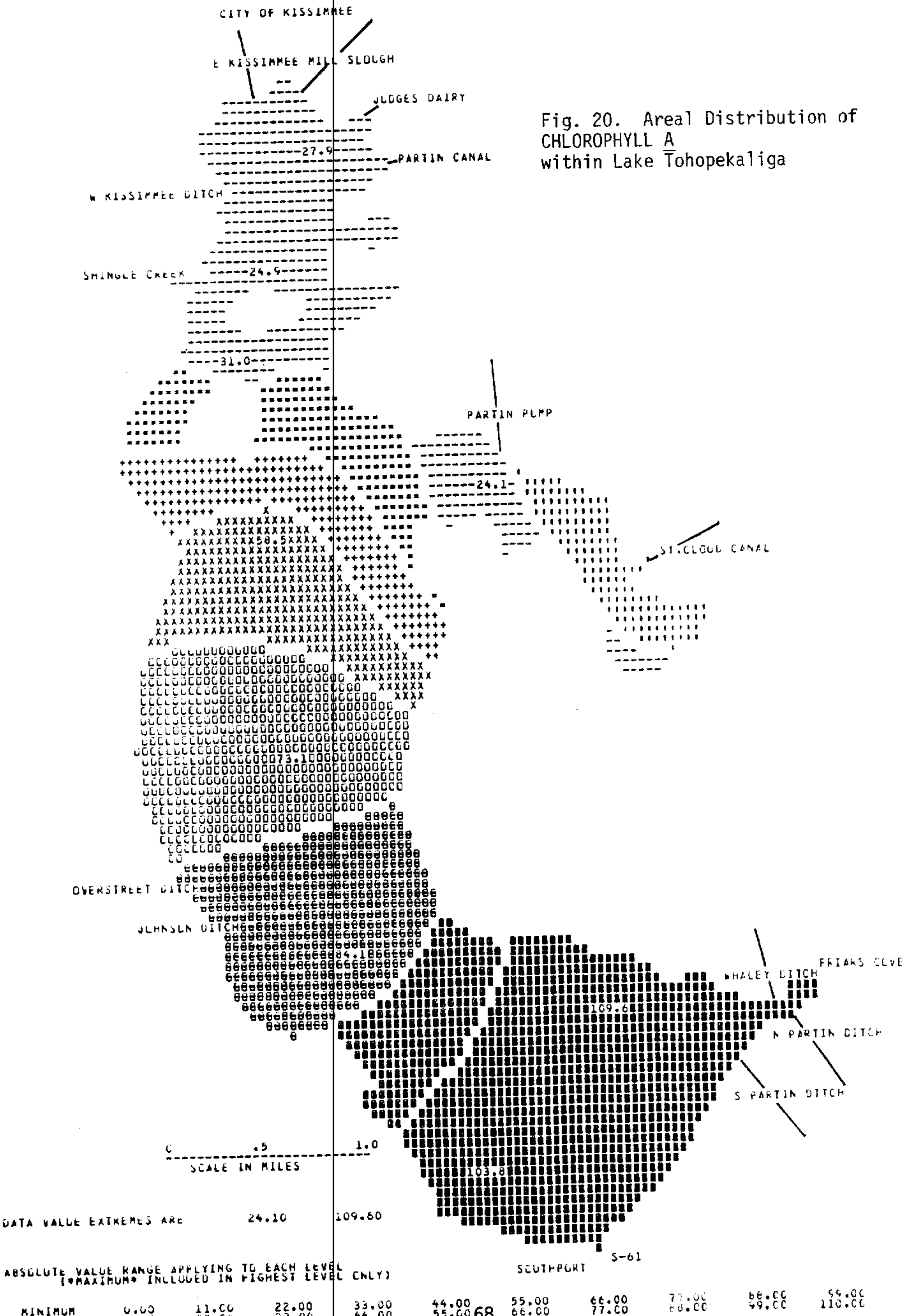
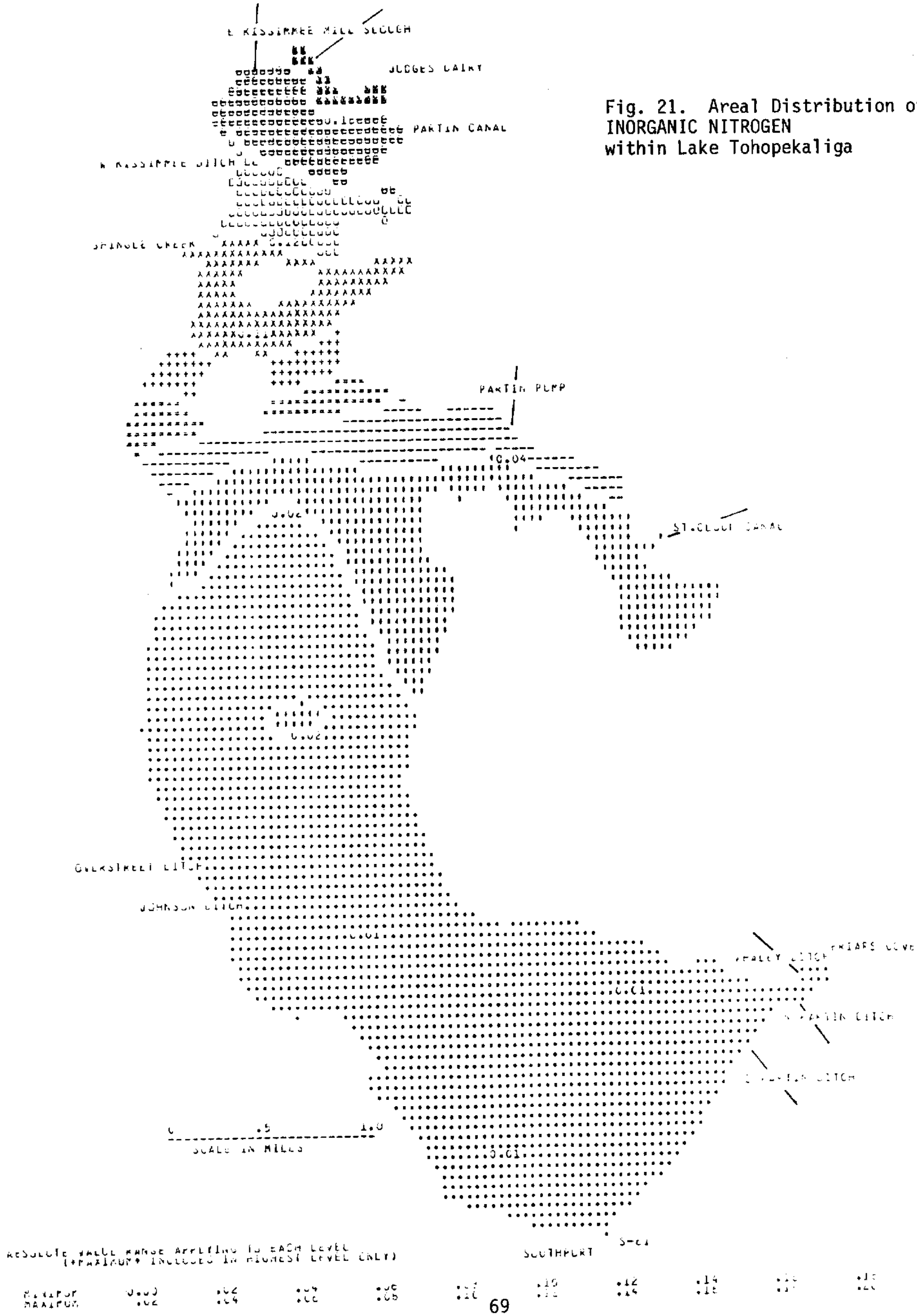


Fig. 20. Areal Distribution of CHLOROPHYLL A within Lake Tohopekaliga

Fig. 21. Areal Distribution of INORGANIC NITROGEN within Lake Tohopekaliga



B05 were below detection limits. Inorganic (ortho) phosphorus also displayed a rapid decrease from north to south (0.546 mg/L at B01 to 0.087 mg/L at B09) (Fig. 22). However, there was still surplus inorganic phosphorus present in the south end of the lake.

The other two water chemistry indices which demonstrate definite areal variations are color and turbidity (Figs. 23 and 24). Color levels in the northern end of Lake Tohopekaliga are relatively high, 155 Pt units at B01, reflecting the high color input of such inflows as Shingle Creek (Avg. 226 Pt units). These levels drop rapidly as evidenced by the narrow concentration gradients in the north end of Lake Tohopekaliga. There seems to be a direct relationship between color and chlorophyll a. It is well known that chlorophyll a levels may be limited by the reduction in available light caused by high color. The north end of Lake Tohopekaliga is characterized by high color/low chlorophyll a. In the south end the relationship is reversed.

The trend for turbidity is similar to chlorophyll a. The northern end is characterized by low level turbidity (3.5 NTU at B01) which increases southward to a maximum site mean of 13.2 NTU at B08. This is most probably related to the increased quantities of algae in the south end of the lake which would add to measurements of turbidity.

It is obvious from the previous discussion that there are some strong differences between the north and the south ends of Lake Tohopekaliga. Not only are parametric means substantially different but also relationships between parameters shift from north to south. Table 14 presents some of these shifts for the north end (B01-B03) versus the south end (B05-B09). Of particular interest are the relationship between nitrogen, phosphorus, and chlorophyll a. The north end was characterized by comparatively lower chlorophyll a and total nitrogen and higher inorganic nitrogen, ortho and

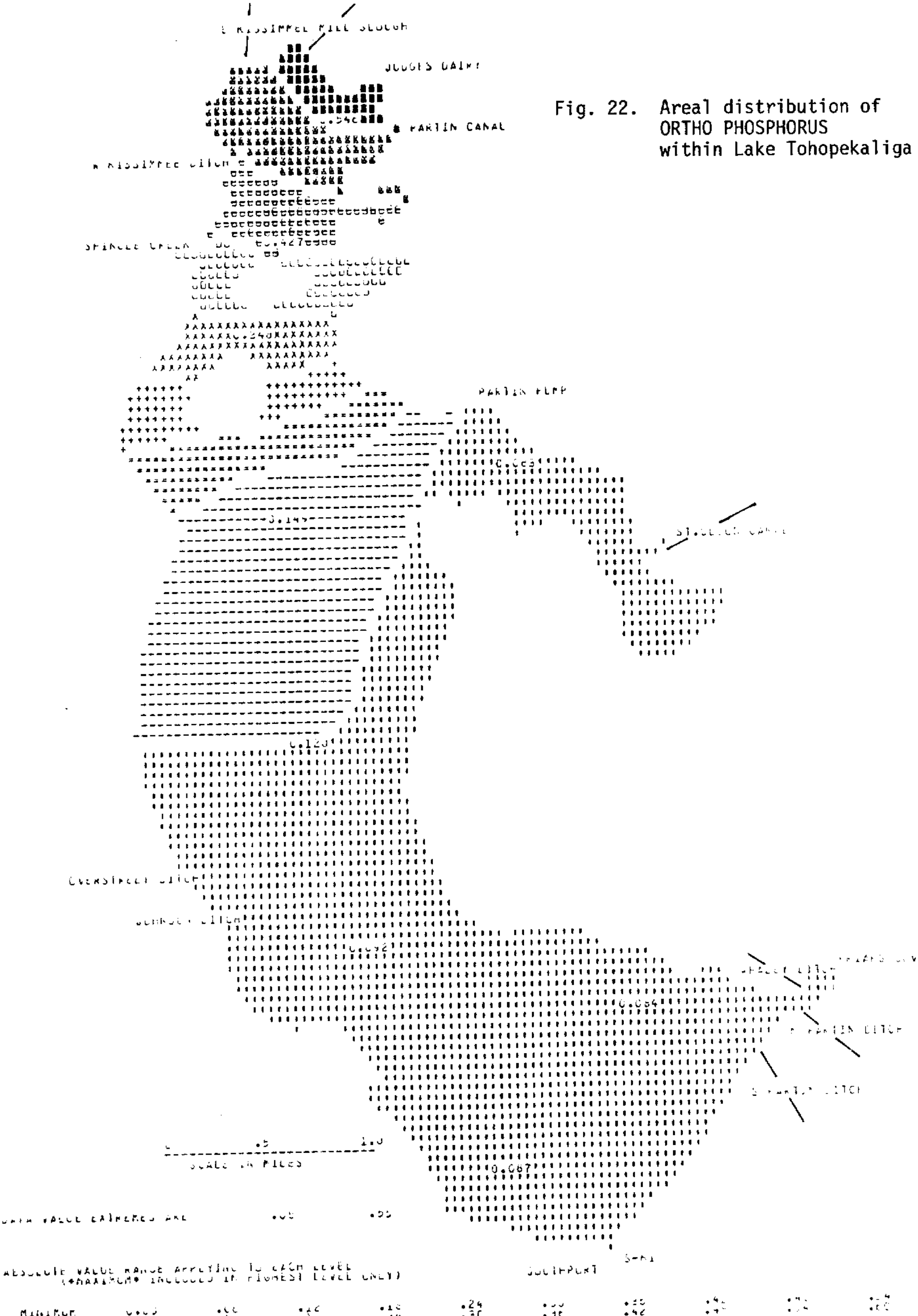


Fig. 22. Areal distribution of ORTHO PHOSPHORUS within Lake Tohopekaliga

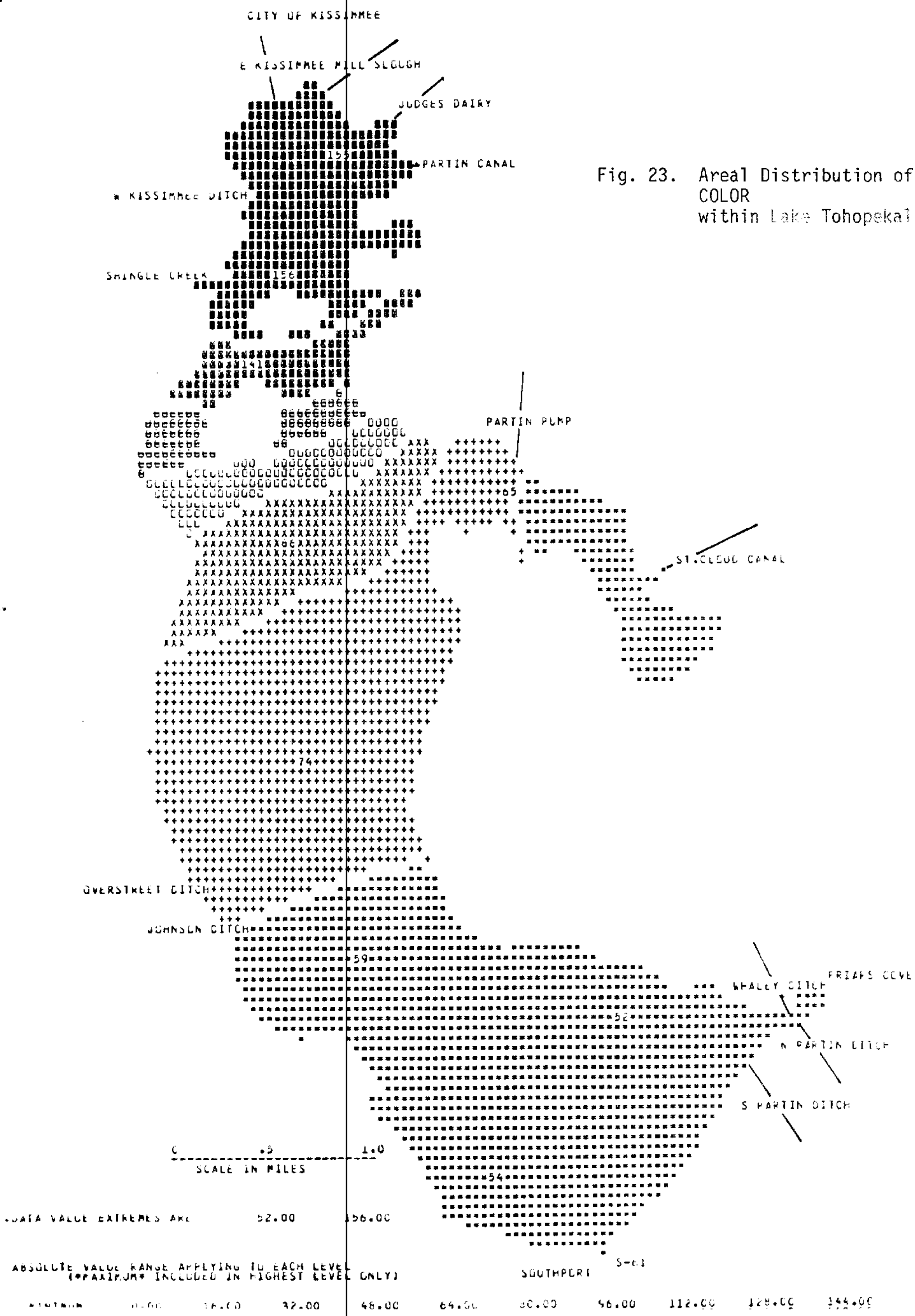


Fig. 23. Areal Distribution of COLOR within Lake Tohopekaliga

Fig. 24. Areal Distribution of
TURBIDITY
within Lake Tohopekaliga

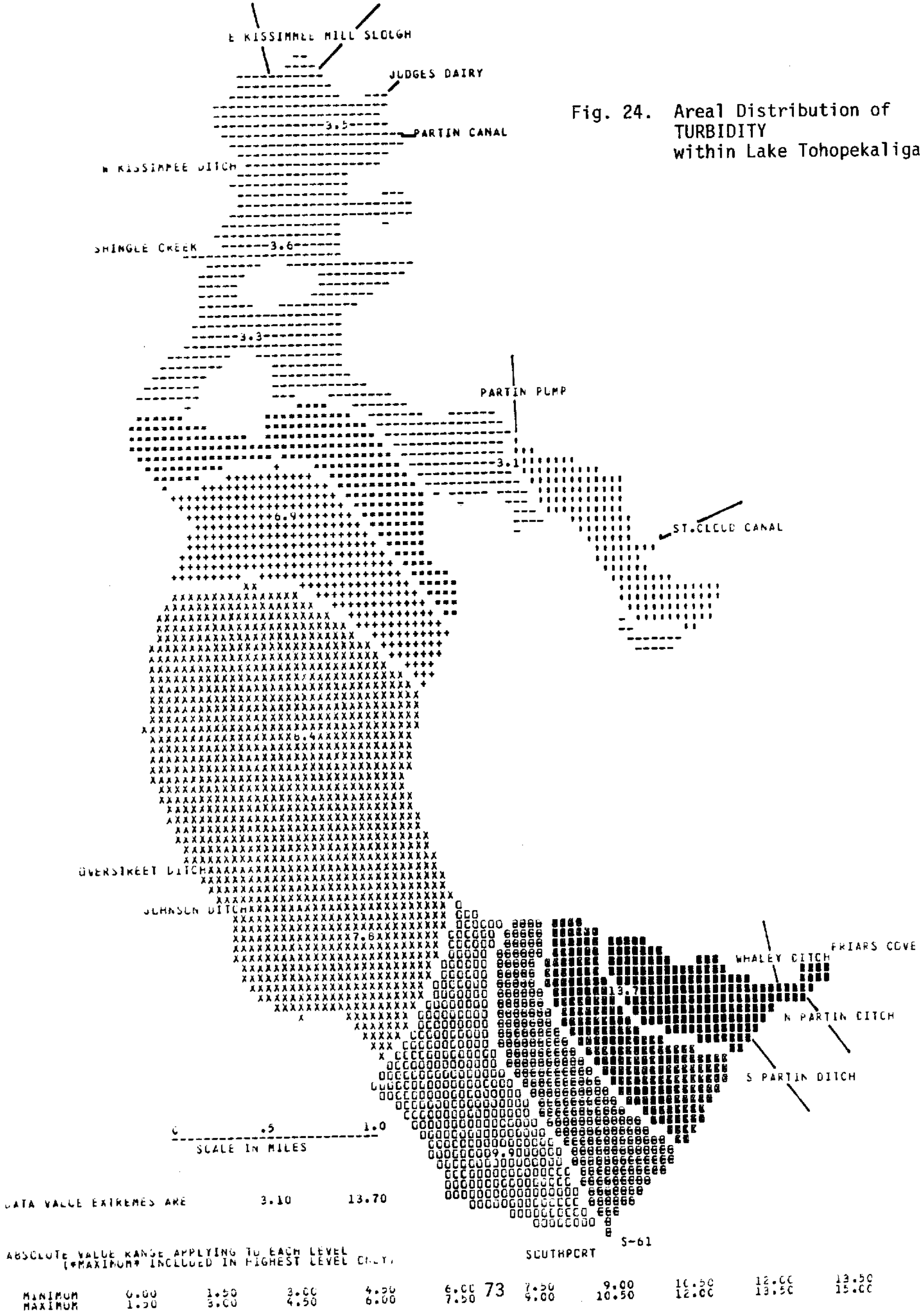


TABLE 14. COMPARISON OF THE NORTH AND SOUTH ENDS OF LAKE TOHOPEKALIGA FOR SELECTED WATER QUALITY PARAMETERS 10/1/81-9/30/82

Station Group	Color (units)	Secchi (meters)	Turb (NTU)	Chlor A (mg/m^3)	Inorg N mg/L	Total N mg/L	OPO_4 mg/L	TPO_4 mg/L	IN/TN	OP/TP	T/N TP	IN/OP
North (B01-B03)	151	0.63	3.5	28	0.013	1.79	0.440	0.536	.07	.72	3.42	0.30
South (B05-B09)	65	0.45	9.2	86	0.002	2.63	0.106	0.288	.01	.37	9.13	0.13

total phosphorus. From the north to the south the total nitrogen to total phosphorus ratios (TN/TP) had increased substantially due to these shifts. Additionally, the inorganic constituent of both nutrients had been reduced substantially in direct relation to the increase in biomass as evidenced by the chlorophyll a values.

Primary Productivity

Any discussion of productivity within an aquatic system must be centered around the equation: net productivity = gross productivity - respiration. That is, that net primary productivity is the rate of photosynthetic synthesis of organic matter in excess of its respiratory utilization during the period of measurement. In actuality this equation will rarely balance due to unavoidable analytical error.

Table 15 presents the estimates of primary productivity done at two stations (B02 and B08) in Lake Tohopekaliga on the 11th of August 1982. As discussed in the section on Spatial Variation, these sites differ in most water chemistry indices.

At station B02 chlorophyll a levels are lower, respiration accounts for only 3% of the gross productivity, and gross productivity measured 2866 mg C/m^3/day. Primary productivity measurements done on the same day at station B09, which is characterized by high chlorophyll a levels, resulted in a gross productivity of 7902 mg C/m^3/day with 12% of that attributed to respiration.

In general, these results are high to very high. Similar analysis done by this agency on Lake Okeechobee resulted in few observations over 1500 mg C/m^3/day.

TABLE 15. RESULTS OF PRODUCTIVITY EXPERIMENT AT STATIONS B02 AND B09 IN LAKE TOHOPEKALIGA

Station	Depth	Date	Chl a (mg/m^3)	Productivity ($mg\ C/m^3/day$) Gross	Resp.	Net
B02 (1)	0.22M	8/11/82	24.9	2866	76	2803
B09 (2)	0.22M	8/11/82	103.8	7902	948	7112

Conditions:

(1) High Color
Low algal turbidity
Secchi .6 meters
Initial time 0940
Final time 1610

(2) Clear to partly cloudy
Low color
High algal turbidity
Secchi .5 meters
Initial time 1040
Final time 1653

Limiting Growth Factors

The ratio of nitrogen to phosphorus, either as inorganic or the total constituents, is often used as an indicator of the limiting growth factor of a lacustrine system (Table 16). Recent limnological investigations have indicated that limits in the production of aquatic biomass are related to the nitrogen to phosphorus ratios. Specifically, a ratio less than 10 indicates a system whose biota is limited by the amount of available nitrogen. A ratio greater than 17 denotes phosphorus limitation. Those lakes which are characterized by nitrogen to phosphorus ratios greater than 10 but less than 17 may be either nitrogen or phosphorus limited (Sakamoto, 1966; Forsberg and Ryding, 1980; E.P.A. National Eutrophication Survey, 1978). The ratio of inorganic nitrogen to inorganic phosphorus for East Lake Tohopekaliga is below 6 at all stations which would indicate nitrogen limitation. However, both inorganic nitrogen and inorganic phosphorus levels in East Lake Tohopekaliga were rarely above the limit of detection, thus making ratio calculations difficult to ascertain. For this reason the total nitrogen to total phosphorus ratios were used to establish nutrient limitation. Ratios ranged from 32.5 to 38.5 within East Lake Tohopekalig, a well within the range of a phosphorus limited lake system. Canfield (1981) and Dye, et al (1975), found that phosphorus is the element most likely limiting algal biomass in Florida lakes.

This is not true of Lake Tohopekaliga, although ortho and total phosphorus concentrations are reduced in the south end of the lake, it is inorganic nitrogen which decreases below detection limits. At all stations within Lake Tohopekaliga the ratio of total nitrogen to total phosphorus is below the 15:1 ratio. The EPA in a recent (12/24/81) report of Lake Tohopekaliga water quality identified <u>Anabena</u> as the major algal genus present during a bloom. Since this blue-green has been previously identified as a

TABLE 16. NITROGEN & PHOSPHORUS RATIOS

		TN/ TP	IN/ IP
East Lake 1/ Tohopekaliga	A01	37.5	4.29
	A02	38.5	5.71
	A03	32.5	1.43
	A04	36.5	1.43
Lake Tohopekaliga	B01	2.92	0.29
	B02	3.39	0.28
	B03	3.95	0.32
	B04	8.26	0.48
	B05	7.52	0.13
	B06	8.68	0.17
	B07	9.17	0.11
	B08	10.20	0.12
	B09	10.07	0.11

1/ Many of the observations for inorganic phosphorus and inorganic nitrogen in East Lake Tohopekaliga are below detection thus ratio is estimated.

photosynthetic organism capable of nitrogen fixation, its growth would doubtfully be limited by any paucity of available nitrogen. The report goes on to conclude that, therefore, phosphorus must be the limiting nutrient to the biomass of Lake Tohopekaliga. This conclusion seems unlikely since the levels of inorganic phosphorus throughout the lake are too high for phosphorus to be limiting. Although results of our phycology analysis do indicate that Anabena is a prevalent algal species, what the EPA report fails to consider is that the rate at which Anabena and other organisms like it can fix atmospheric nitrogen is limited and, therefore, Lake Tohopekaliga would still be considered "nitrogen limited".

Trophic State Analysis and Model Evaluation

One of the primary objectives of this study is to assess the trophic state and eutrophication potential of each lake. The ultimate goal of this project is to set maximum total nutrient loading allocations for each lake, basin, or sub-basin that will prevent eutrophication of the lakes. To achieve this goal, nutrient input-output models will be evaluated to determine if they can accurately predict the lake's trophic state based on nutrient loadings and other hydrological characteristics. Then, these models can be used to determine what level of nutrient loading will produce the desired trophic state.

To increase the confidence of this analysis, more than one year of data will be collected because such factors as rainfall, nutrient runoff, lake water quality, and basin hydrology will vary from year to year. For this reason, final assessments and recommendations will not be made until this study is completed. This chapter provides a preliminary assessment of the trophic states of Lake Tohopekaliga and East Lake Tohopekaliga and tests the applicability of certain nutrient input-output models in order to provide guidance for future work.

This analysis is similar to the one presented by Federico et al (1981) for Lake Okeechobee (SFWMD Technical Publication #81-2). The reader is referred to that report for an explanation of the theory and development of nutrient input-output models (also referred to as nutrient loading models or mass balance models). Federico et al tested several models, including some developed from Florida lake data, for their ability to correctly predict the trophic state and in-lake nutrient concentrations of Lake Okeechobee. They found that the best model for this lake was the Vollenweider (1976) equation modified to fit Florida lakes. This model was then used as a basis for developing a nutrient control strategy for the lake basin. Before testing this and other models on the Kissimmeee lakes, the trophic state of each lake will be determined based on various indicators and a trophic state index.

Trophic State

According to other studies, East Lake Tohopekaliga may be characterized as mesotrophic and Lake Tohopekaliga may be described as eutrophic (Baker et al 1981; Canfield 1981; ECFRPC 1978; Federico and Brezonik 1975; U.S. EPA 1977a, 1977b, 1980).

Trophic state may be judged by comparing observed levels of certain water quality parameters with their critical values (above or below which a eutrophic condition could be expected). These trophic state indicators, primarily total and ortho phosphorus, total and inorganic nitrogen, Secchi disk transparency, and chlorophyll a, were used by Federico et al (1981) in evaluating Lake Okeechobee. From among the several sources listed by Federico et al, Kratzer (1979) is the only reference that presents critical values developed from a Florida data base. Consequently, these values are probably the most appropriate for comparison with the water quality of the Kissimmee lakes. According to Kratzer, a eutrophic condition can be expected if chlorophyll a, total phosphorus, and total nitrogen are above 10.0 mg/m^3, 0.040 mg/L, and 0.90 mg/L, respectively. Based on these criteria, Lake Tohopekaliga would be classified as eutrophic, since the average values of these parameters are each above their critical values. East Lake Tohopekaliga, on the other hand, cannot be classified as eutrophic based on these parameters (see Table 13 for average lake concentrations).

Trophic conditions can be quantified by means of a trophic state index (TSI) which may be based on one or several variables. The advantages of a trophic state index are that lakes can be ranked against each other and that historical changes in trophic state can be quantified, thereby allowing an assessment of the impact of cultural perturbations.

Trophic state indices based on Secchi depth, chlorophyll a, total phosphorus, and total nitrogen are used in this report. These parameters are judged to be the most immportant in determining trophic state. The trophic state and TSI associated with various levels of these water quality parameters are shown in Table 17. Carlson (1983) states that chlorophyll is the index of choice for representing trophic state, since this parameter best reflects the actual amount of algal biomass in the water, and the index is intended to classify lakes on the basis of algal biomass. The other indices supplement the chlorophyll TSI and usually will coincide with it.

Further, only the lower of the two nutrient indices should be used since the lesser of TSI (TP) and TSI (TN) should represent the limiting nutrient in the lake.

Based on the chlorophyll TSI, Lake Tohopekaliga is more eutrophic than East Lake Tohopekaliga. Lake Tohopekaliga's TSI (CHA) is 72.0 which indicates a borderline hypereutrophic condition (Table 18). Trophic state indices for Secchi depth and total nitrogen are slightly less but still indicate a eutrophic to hypereutrophic condition. Note that the TSI (TP value of 86.6) is much higher than the other indices, suggesting that this lake is nitrogen limited and contains more phosphorus than the phytoplankton can utilize. This is confirmed by the low TN:TP ratio and high orthophosphate levels that were discussed earlier. The TSI (CHA) of East Lake Tohopekaliga is 46.9 which suggests that this lake is mesotrophic. The other TSI's are similar and agree with this conclusion.

TABLE 17. TROPHIC STATES ASSOCIATED WITH CARLSON'S TSI: (From Federico et al 1981)

TSI	Trophic State	Water Transparency (Secchi Disk, m)	Chlorophyll a (microgram/L)	Total Phosphorus (microgram P/L)	Total Nitrogen (mg N/L)
0	ultraoligotrophic	64	0.04	0.75	0.02
10	ultraoligotrophic	32	0.12	1.5	0.05
20	ultraoligotrophic	16	0.34	3	0.09
30	oligotrophic	8	0.94	6	0.18
40	oligotrophic	4	2.6	12	0.37
45	mesotrophic	2.8	4.4	17	0.52
50	mesotrophic	2	7.3	24	0.74
53	eutrophic	1.6	10	30	0.92
60	eutrophic	1	20	48	1.47
70	hypereutrophic	0.5	56	96	2.94
80	hypereutrophic	0.25	154	192	5.89
90	hypereutrophic	0.12	427	384	11.8
100	hypereutrophic	0.06	1183	768	23.6

where: TSI (SD) 1/ = 10 (6 - ln (SD)/ln 2), SD in meters

TSI (CHA) 1/ = 10 (6 - (2.04 - 0.68 ln (CHA))/ln 2), CHA in microgram/L

TSI (TP) 1/ = 10 (6 - ln (48/TP)/ ln 2), TP in microgram/L

TSI (TN) 2/ = 10 (6 - ln (1.47/TN)/ln 2), TN in mg/L

1/ from Carlson (1977)

2/ from Kratzer and Brezonik (1981)

TABLE 18. TROPHIC STATE INDEX RESULTS

	East Lake Tohopekaliga	Lake Tohopekaliga
TSI (SD) 1/	49.5	68.6
TSI (CHA) 2/	46.9	72.0
TSI (TP) 3/	47.4	86.6
TSI (TN) 4/	49.7	66.6

1/ TSI (SD) = 10 (6-ln (SD)/ln 2) (Carlson 1977)

2/ TSI (CHA) = 10 (6-(2.04-0.68 ln (CHA))/ln 2) (Carlson 1977)

3/ TSI (TP) = 10 (6-ln(48/TP)/ln 2) (Carlson 1977)

4/ TSI (TN) - 10 (6-ln (1.47/TN)/ln 2) (Kratzer and Brezonik 1981)

Aplicability of Phosphorus Input-output Models

The modified Vollenweider (1976) models for phosphorus and nitrogen are expressed as follows:

$$TP = 0.682\ (L_P/(q_s\ (1 + \surd\tau_\omega)\ )\ )^{0.934}$$

$$TN = 1.29\ \ (L_N/(q_s\ (1 + \surd\tau_\omega\ )\ )\ )^{0.858}$$

where,

TP and TN are the predicted in-lake concentrations of total phosphorus and total nitrogen (mg/L)

L_P and L_N are the annual loading rates of total P and total N per unit of lake surface area (g/m^2-yr)

q_s is the hydraulic loading rate (m/yr)

τ_ω is the water residence time (years)

Substituting the East Lake Tohopekaliga values for L_P, q_s, and τ_ω, the predicted TP concentration is 0.047 mg/L. This value is over twice as large as the average measured concentration of 0.020 mg/L. For Lake Tohopekaliga, the predicted TP value is 0.163 mg/L, 46% lower than the measured concentration of 0.303 mg/L. Thus, although the modified Vollenweider (1976) model is a good predictor of Lake Okeechobee phosphorus concentrations, it does not appear to work as well for these lakes for this year of study. Simple equations of this type cannot be expected to always perform well for each lake to which they are applied because each lake has unique characteristics that are unaccounted for by the model. However, there are several identifiable reasons to expect significant errors in the Vollenweider model predictions.

First and most important is the inaccuracy of the Lake Tohopekaliga water budget. Since the model runs on hydrological data, an accurate water budget is extremely important for lake modeling. As shown earlier, the water budget error was 49.6%, which means that a volume of water equal to one-half the volume of the lake was unaccounted for in the budget. This error alone makes the application of the model to this lake quite tenuous.

Violations of some assumptions used in developing this model may also contribute to model error. These assumptions are:

(1) The lake acts as a homogeneous, constantly stirred reactor. It is well-mixed, both vertically and horitzontally.

(2) Lake inputs are constant throughout the year.

(3) Lake phosphorus concentrations are only influenced by external inputs.

(4) The lake is in a steady state, that is, phosphorus concentrations are not changing over time.

Lake Tohopekaliga violates each of these assumptions. Although the water column is well-mixed, there are significant areal variations in water quality from north to south. Lake inputs were not constant in 1981-82; inflow was much greater during the latter half of the year. Lake phosphorus concentrations are probably influenced by internal loading processes such as resuspension and diffusion of phosphorus from the sediment in addition to external inputs. Finally, the lake does not appear to be in steady state with respect to phosphorus concentrations. As Table 19 shows, average TP concentrations in the south end of the lake increased from 1974 to 1979, but are lower in 1981-83. In fact, data collected over the last two years show that phosphorus concentrations are decreasing. (Data collected outside the October 1981-September 1982 period of study is included in Table 19 to better illustrate this trend). This decreasing trend is evident as is shown over the entire lake. A conclusion on whether this decline is due to reduced Shingle Creek TP concentrations or is just a cyclical phenomenon must await several

TABLE 19. HISTORICAL TRENDS IN SOUTHERN LAKE TOHOPEKALIGA PHOSPHORUS, NITROGEN, AND CHLOROPHYLL CONCENTRATIONS 1/

Year	TP (mg/L)	TN (mg/L)	Chlorophyll (mg/m^3)
1972	-	-	33.6
1974	0.160	1.75	-
1975	0.196	1.86	-
1976	0.384	2.42	88.6
1977	0.309	2.39	75.0
1978	0.312	1.94	77.9
1979	0.443	2.45	126
8/81-7/82	0.336	3.32	134.2
9/81-8/82	0.309	3.32	124.4
10/81-9/82	0.303	3.10	109.6
11/81-10/82	0.287	2.82	101.0
12/81-11/82	0.277	2.66	96.7
1/82-12/82	0.270	2.53	99.0
2/82-1/83	0.266	2.48	99.0
3/82-2/83	0.269	2.25	81.4
4/82-3/83	0.279	2.18	78.0

1/ Years 1972 - 1979 are from U.S. EPA (1980). Results from 1981 - 1983 are from this study and are from station B09. Both sampling locations are approximately 1.5 miles northwest of the lake outlet, S-61.

more years of data collection, but the data collected so far suggest that the trophic state of Lake Tohopekaliga is improving. If so, it could be expected that trophic state improvement would lag behind the rate of phosphorus loading reductions, thus causing the nutrient loading model to underpredict lake phosphorus concentrations.

To further examine the performance of the modified Vollenweider (1976) model, it was tested using earlier Lake Tohopekaliga data (U.S. EPA 1980). Although the accuracy of the EPA water budget is unknown, the reported inflows significantly exceed the reported outflows. Using a phosphorus loading rate of 2.48 g/m^2-yr, a hydraulic loading rate of 4.21 m/yr and a water residence time of 0.46 years, the predicted TP value is 0.257 mg/L which is only 17 percent lower than the 1974-79 average concentration in the south end (0.301 mg/L). Thus, the model performs better but also underestimates TP for the period prior to 1981-82.

The applicability of other nutrient loading models to East Lake Tohopekaliga and Lake Tohopekaliga was also tested (Table 20). Like the modified Vollenweider (1976) model, the modified Vollenweider (1975) and modified Dillon and Rigler (1975) models were developed from a Florida lake data base. The other models were developed from a large number of natural, temperate zone lakes (Canfield and Bachmann, 1981).

Based on one year of data, it is impossible to conclude which model is best for each lake. All models overestimated TP in the East Lake and underestimated TP in Lake Tohopekaliga which demonstrates that the error in prediction is not peculiar to the modified Vollenweider (1976) model. The best predictions were provided by the modified Dillon and Rigler (1975) model.

TABLE 20. COMPARISON OF PHOSPHORUS INPUT-OUTPUT MODELS

	TP (mg/L)	
	East Lake Tohopekaliga	Lake Tohopekaliga
Measured Concentrations	0.020	0.303
Predicted Concentrations		
Modified Vollenweider (1976); 1/ (Federico et al 1981)		
$TP = 0.682\ (L_P/(q_s\ (1 + \sqrt{\tau_\omega})\ )\ )^{0.934}$	0.047	0.163
Modified Vollenweider (1975); 1/ (Kratzer 1979)		
$TP = 0.843\ (L_P/(10 + q_s)\ )^{0.795}$	0.047	0.157
Modified Dillon and Rigler (1975); 1/ (Kratzer 1979)		
$TP = 0.748\ (L_P(1 - R_{exp})/q_s)^{0.862}$	0.031	0.233
Where $R_{exp} = (P_{in} - P_{out})/P_{in}$		
Canfield and Bachmann (1981) 2/		
$TP = L_P/(z(0.162\ (L_P/z)^{0.458} + (1/\tau_\omega)\ )\ )$	0.053	0.165
$TP = 0.8\ L_P/(z(0.0942\ (L_P/z)^{0.422} + (1/\tau_\omega)\ )\ )$	0.062	0.205
Modified Larsen and Mercier (1976); 2/ (Canfield and Bachmann 1981)		
$TP = (L_P(1-R)\ )/q_s$	0.049	0.189
Where $R = 1/(1 + 0.747\ (1/\tau_\omega)^{0.507})$		

1/ TP in mg/L; Lp in g/m^2-yr

2/ TP in mg/m^3; Lp in mg/m^2-yr

Applicability of Nitrogen Input-output Models

Since East Lake Tohopekaliga is phosphorus-limited, a phosphorus loading model should be used in managing this lake. In contrast, Lake Tohopekaliga is nitrogen-limited, so it might be appropriate to use a nitrogen input-output model to compute maximum allowable nitrogen loading rates. However, it was shown in the previous chapter that a major portion of lake nitrogen is probably fixed from the atmosphere and/or cycled up from the sediments; therefore, it is probably impossible to control algal growth by reducing nitrogen inputs alone. Instead, if external phosphorus inputs are reduced to the point where the limiting nutrient becomes phosphorus, then the competitive advantage may shift away from nitrogen-fixing blue-green algae to more desirable algal forms (Smith, 1982). Thus, both phosphorus and nitrogen concentrations as well as algal biomass might be decreased by reducing phosphorus loadings. However, it has been argued that both phosphorus and nitrogen loadings should be controlled, so three nitrogen loading models (Table 21) have been applied to the lake. The modified Vollenweider (1976) nitrogen model was chosen as the best model for Lake Okeechobee (Federico et al 1981). Table 21 shows that as with phosphorus, this model underestimated the average lake nitrogen concentration. The predicted value is 1.54 mg/L compared to the measured value of 2.33 mg/L. The other two models came closer to correctly predicting the actual nitrogen concentration; however, as indicated before, none of these models are realistic because they ignore the importance of internal loading processes. They also suffer from the same problems discussed in the evaluation of phosphorus loading models, particularly the inaccuracy of the Lake Tohopekaliga water budget.

TABLE 21. COMPARISON OF NITROGEN INPUT-OUTPUT MODELS

	Lake Tohopekaliga TN (mg/L)
Measured Concentration	2.33
Predicted Concentrations	
Modified Vollenweider (1976); (Federico et al (1981)	
$TN = 1.29\ (L_N/q_s\ (1 + \sqrt{\tau_\omega})\ )\ )^{0.858}$	1.54
Modified Vollenweider (1975); (Kratzer 1979)	
$TN = 2.85\ (L_N/(10 + q_s)\ )^{0.216}$	2.63
Modified Dillon and Rigler (1975); (Kratzer 1979)	
$TN = 0.899\ (L_N(1 - R_{exn})/q_s)^{0.976}$	1.94
where $R_{exn} = (N_{in} - N_{out})/N_{in}$	

Chlorophyll Models

Several projects are now underway to improve the effluent quality of municipal wastewater and to control nonpoint-source runoff in the Lake Tohopekaliga basin. These projects are designed to reduce nutrient loadings to the lake, resulting in an improved trophic state and decreased phytoplankton biomass. Since the ultimate management goal is to reduce algal biomass, it would be desirable to determine how much biomass would decrease as a result of a given reduction in nutrient loading. This can be accomplished in two steps. The first step is to predict in-lake nutrient concentrations from the expected nutrient loading rates using a suitable input-ouput model. Then, assuming that algal biomass is limited by phosphorus or nitrogen, future chlorophyll a concentrations can be estimated from the predicted nutrient values through the use of a regression equation relating chlorophyll to phosphorus and/or nitrogen.

Several researchers (Sakamoto 1966; Dillon and Rigler 1974; Jones and Bachmann 1976; Carlson 1977) have found that chlorophyll and total phosphorus are highly correlated. Because many Florida lakes are nitrogen-limited, these lakes also exhibit a strong relationship between chlorophyll and total nitrogen (Baker et al 1981; Canfield 1983). Usually, chlorophyll-nutrient regression equations are formulated using average values from a large number of lakes. Some models developed from Florida lake data are shown in Table 22. Most models are linear regressions using either TP or TN as the independent variable. Because Lake Tohopekaliga is nitrogen-limited, the use of a chlorophyll-nitrogen regression would be more appropriate. However, Canfield (1983) and Smith (1982) indicate that highly eutrophic lakes tend to be nitrogen-limited (i.e. have a low TN:TP ratio) while less productive lakes are usually limited by phosphorus. Differences in the TN:TP ratio account for

TABLE 22. APPLICABILITY OF CHLOROPHYLL MODELS TO THE SOUTH END OF LAKE TOHOPEKALIGA

	1976 1/	1977 1/	1978 1/	1979 1/	1981-2/ 1982
Measured TP concentration (mg/m3)	384	309	312	443	290
Measured TN concentration (mg/m^3)	2422	2387	1943	2453	3000
Measured Chlorophyll *a* concentration (mg/m^3)	88.6	75.0	77.9	126	107
Predicted Chlorophyll Concentrations					
This study 5/					
Chl a = 58.4 (TN) - 161.2 (TP) - 5.82 (TN/TP) + 30.09	73.0	74.8	57.1	69.8	- 6/
Baker et al (1981) 3/					
log (Chl a) = 0.79 log (TP) - 0.41	42.8	36.1	36.3	47.9	34.3
log (Chl a) = 1.46 log (TN) + 1.03	39.0	38.2	28.3	39.7	53.3
Smith (1982) 4/					
log (Chl a) = 0.374 log (TP) + 0.935 log (TN) - 2.488	43.9	40.0	33.1	46.9	48.3
Canfield (1983) 4/					
log (Chl a) = 0.269 log (TP) + 1.06 log (TN) - 2.49	62.0	57.6	46.4	65.3	72.1
log (Chl a) = 0.774 log (TP) - 0.15	70.8	59.9	60.3	79.1	57.0
log (Chl a) = 1.38 log (TN) - 2.99	47.9	46.9	35.3	48.7	64.3

1/ Measured concentrations for 1976-79 from south end of lake (U.S. EPA 1980)

2/ Measured concentrations for 1981-82 from this study (station B09)

3/ TP and Chl a in mg/m^3, TN in mg/L

4/ All units in mg/m^3

5/ TP and TN in mg/L, Chl a in mg/m^3

6/ 1981-82 predicted value not shown since 1981-82 data was used in calibrating this model.

much of the scatter observed in linear regression plots. To account for the influence of the TN:TP ratio, Canfield (1983) and Smith (1982) included both TN and TP in their equations. These multiple regression equations have less model error than equations based on only one nutrient parameter. Because nutrient loading reductions will probably lead to a higher TN:TP ratio in Lake Tohopekaliga, a multiple regression model of this type is probably the most suitable for predicting future chlorophyll concentrations in this lake.

In examining the data from this study, we also found that chlorophyll is highly correlated with TP and TN for each of the two lakes. From these relationships, multiple regression equations could be formulated for East Lake Tohopekaliga and Lake Tohopekaliga. The Lake Tohopekaliga model is given in Table 22.

Using average TN and TP values from southern Lake Tohopekaliga, we tested the ability of these models to estimate chlorophyll concentrations in this area of the lake. Average observed values for 1976-79 were taken from the U.S. EPA (1980) report and 1981-82 values are from this study. All of the models tended to underestimate actual chlorophyll levels. The model developed in this study was among those that performed the best. These results are, of course, preliminary and will be re-examined after more data becomes available.

Given the strong correlation between chlorophyll and nutrients in these two lakes, it should be possible, by the end of this study, to develop a model specific to these lakes that will allow predictions of future chlorophyll concentrations. Going a step further, an improvement in Secchi disk transparency could be predicted from the relationship of transparency with chlorophyll and color. Theoretically then, the degree of improvement in water clarity expected from a given reduction in nutrient loading could be predicted from a series of these mathematical models.

The main problem with this modeling effort lies with the uncertainty associated with each model. This uncertainty is compounded when the predicted value from one model is used to predict the value of another parameter in another model. We hope to reduce this uncertainty by using chlorophyll and Secchi depth models developed specifically for these lakes. But first, it must be shown that lake nutrient concentrations can be reliably predicted using a nutrient loading model. As discussed earlier, nutrient loading models applied to Lake Tohopekaliga were not very successful for the year 1981-82. To improve the predictive ability of these models, an accurate water budget must be available. Modeling could also be improved by considering seasonal and spatial variations and internal loading processes. For instance, proposals are now being evaluated to quantify the amount of nutrients released into the water column via sediment resuspension and to determine the magnitude of nitrogen fixation in Lake Tohopekaliga.

The following conclusions can be drawn from these results. Note that these are preliminary conclusions and may be changed after the second and third years of data are analyzed.

(1) Trophic state indicators and a multivariate trophic state index classify East Lake Tohopekaliga as mesotrophic and Lake Tohopekaliga as eutrophic to hypereutrophic.

(2) The modified Vollenweider (1976) model overestimated the average East Lake Tohopekaliga phosphorus concentration and significantly underestimated TP for Lake Tohopekaliga. Several possible reasons exist for the error in the latter prediction, but the most important factor is probably the inaccuracy of the Lake Tohopekaliga water budget. In the future, this model should be evaluated along with other models to determine the best model(s) for these lakes.

(3) If it is necessary to control nitrogen inputs to Lake Tohopekaliga, it will probably be difficult to determine maximum allowable nitrogen loadings from a nitrogen input-output model unless internal nitrogen loadings are quantified and incorporated in the equation.

(4) Because lake chlorophyll is significantly correlated with phosphorus and nitrogen concentrations, future chlorophyll concentrations might be predicted from future nutrient loading rates.

Lakes Cypress, Hatchineha, and Kissimmee

As part of the SFWMD's assessment of the Upper Kissimmee Chain of Lakes water quality sampling of Lakes Cypress, Hatchineha, and Kissimmee was initiated in April of 1982. Reconnaissance sampling trips were conducted in April and May, and in July 1982 the lower three lakes were added permanently to this study. Sixteen stations were established in these three lakes and the conveyance canals which interconnect them to Lake Tohopekaliga (Fig. 25). Discharge through the S-61 gravity structure at the south end of Lake Tohopekaliga flows down the C-35 canal into Lake Cypress. The water may then free flow down the C-36 canal into Lake Hatchineha, through Hatchineha down the C-37 canal into Lake Kissimmee, and ultimately discharges by S-65 gravity gate into the Kissimmee River. The lower three lakes are in a free flow condition since there are no control structures between S-61 and S-65.

The section on Lake Tohopekaliga water quality indicated a lake in an enriched condition prone to nuisance algal blooms. Since the S-61 structure, which constitutes the only surface outflow from Lake Tohopekaliga, discharges into the lower three lakes it would be a good assumption that discharge through S-61 has a degree of impact on the water quality in Lakes Cypress, Hatchineha, and Kissimmee.

During the study period, S-61 was relatively active discharging a total of 245,914 acre-feet for the six month period (4/1/81 - 9/30/82). With the exception of a three week period in the beginning of June and two one week periods in September, S-61 continuously discharged. All samples were collected either during or immediately after S-61 discharge activity. therefore, it can be assumed that the water quality presented for the lower three lakes reflects the impact of S-61 discharge.

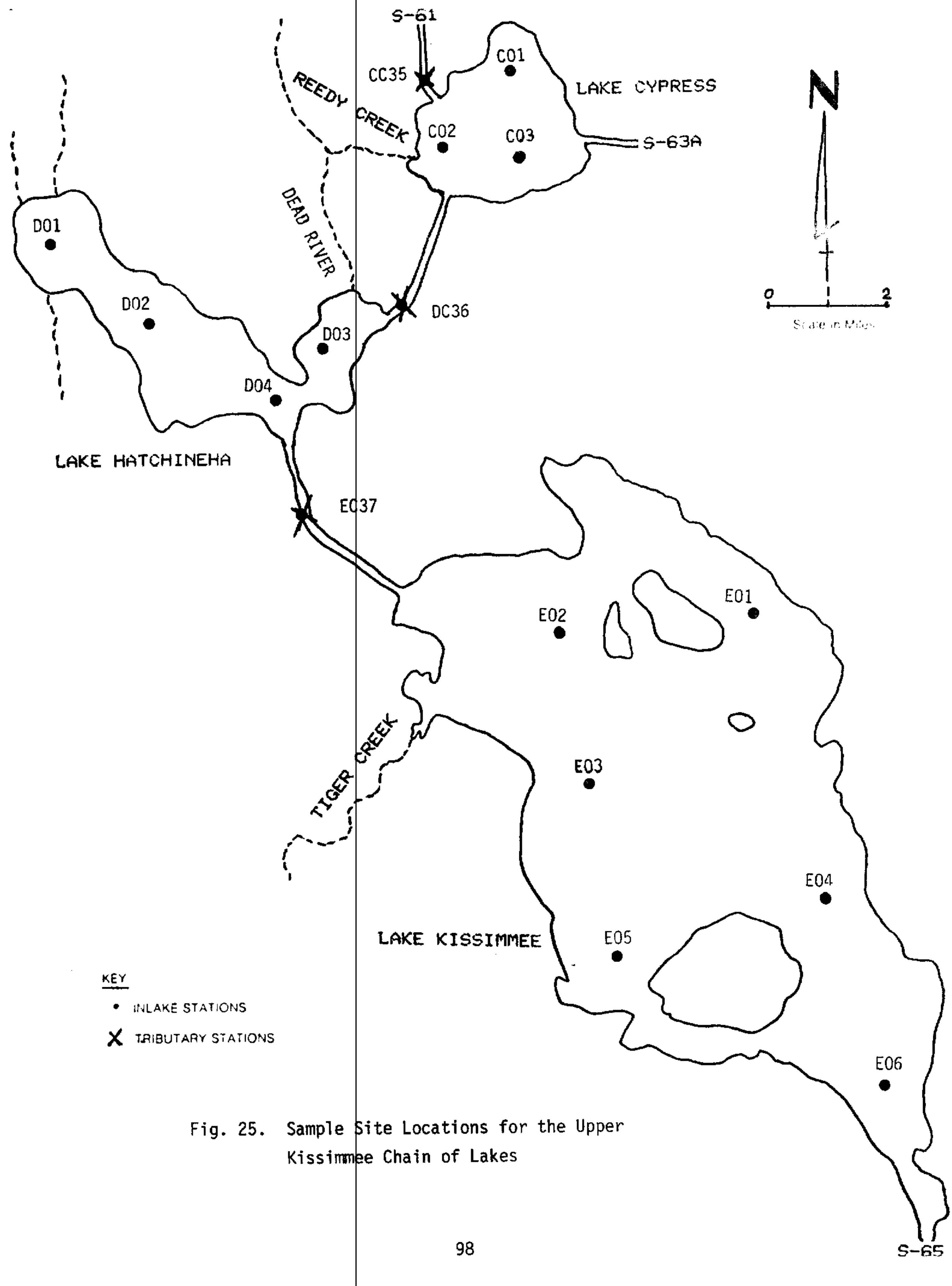


Fig. 25. Sample Site Locations for the Upper Kissimmee Chain of Lakes

Acknowledging that the water quality data on the lower three lakes is the result of only five monthly trips, the water quality data presented here, although extremely preliminary, does demonstrate some significant trends. Table 23 presents canal and whole lake averages for some major water chemistry parameters. For the lower three lakes these values are summer wet season values only and these parameters, as observed in the upper two lakes, may be seasonally biased. Therefore, grand mean values for Lakes Tohopekaliga and East Tohopekaliga for the same time frame are also presented for comparison.

A major trend is a general improvement in some water quality indices in the lakes from north to south. Specific conductance, ortho and total phosphorus, and chlorophyll a all demonstrate a general decrease from Lake Tohopekaliga south. Other parameters such as total nitrogen, inorganic nitrogen and chlorides display an overall decrease from Lakes Tohopekaliga to Kissimmee with some peak intermittent values. Another trend evident in Table 23 is a general elevation of some parameters in the connecting canals, followed by a decrease in each lake, followed by an elevation again in the next canal. This see-saw effect from C-35 south to Lake Kissimmee was noted for total nitrogen and ortho and total phosphorus. It may be a result of the discharge of drain fields into these conveyance canals or a function of the suspension of bottom sediments caused by changes in stream velocity, sediment type, and bottom contours.

TABLE 23. COMPARISON OF GENERAL LAKE AND CONNECTING CANAL WATER QUALITY 2/

Parameter 1/	East Toho	Toho	C-35	Cypress	C-36	Hatchineha	C-37	Kissimmee
pH (units)	6.31	8.22	8.67	8.32	7.87	7.31	7.40	8.05
Temp. (^{o}C)	26.6	27.7	27.3	27.5	27.4	28.7	28.2	27.8
Cond. (micromhos/cm)	142.0	242.0	266.0	244.0	237.0	208.0	223.0	204.0
D.O.	7.9	8.0	8.0	8.6	7.8	6.8	6.3	7.7
Inorg. N	0.02	0.02	0.01	0.02	0.02	0.05	0.08	0.02
Total N	0.69	2.01	2.90	2.33	3.03	2.26	2.38	1.90
OPO_4	0.004	0.148	0.093	0.041	0.055	0.024	0.041	0.006
TPO_4	0.020	0.290	0.269	0.181	0.221	0.107	0.160	0.053
Color (PTU)	36.0	85.6	56.0	81.0	117.0	213.0	184.0	86.0
Turb (NTU)	1.9	7.3	10.3	9.3	10.5	7.0	6.5	7.6
Secchi (meters)	1.75	0.57	-	0.39	-	0.42	-	0.60
Alk. (meq/L)	0.14	0.70	0.81	0.66	0.70	0.58	0.66	0.62
Cl	21.3	26.6	28.5	27.4	26.9	20.7	22.3	20.7
Chlorophyll a (mg/m^3)	5.2	61.0	-	60.3	-	33.0	-	29.7

North -- South

1/ All values in mg/L unless otherwise specified

2/ 4/1/82 - 9/30/82 period of study

Summary of Predominant Algal Species

Phytoplankton samples were collected concurrently with the measurement of water quality parameters at eight sites within the Upper Kissimmee Chain of Lakes during April and August 1982. Duplicate, composite (surface to 2 meters depth) water samples were collected from stations A04, B02, B05, B08, C02, D04, E02, and E05 in Lakes East Tohopekaliga, Tohopekaliga, Cypress, Hatchineha and Kissimmee (Figure 2). Samples were preserved in the field using neutralized 5% formalin. Environmental Sciences Division biologists enumerated and identified phytoplankton organisms to the genera and species level using an inverted microscope (400X magnification) and the Utermohl (1958) sedimentation technique.

Five major groups of algae (filamentous and coccoid blue-greens, green algae, diatoms, and dinoflagellates) were found to dominate the Kissimmee lakes phytoplankton. Table 24 presents a breakdown of the distribution of these five groups within the Upper Kissimmee Chain during April and August 1982. Figures 26 and 27 summarize the relative abundance of the five major groups at all eight sites. Appendix E lists all phytoplankton species found in the lakes.

April, 1982

Filamentous and coccoid blue-greens (Cyanophyceae) were the dominant flora in Lakes Cypress, Hatchineha, and the south end of Lake Tohopekaliga during April 1982. Three filamentous blue-greens were numerically important, *Lyngbya contorta*, *L. limnetica* and the potential nitrogen fixing species, *Anabena spiroides*. During April 1982, *A. spiroides* dominated the plankton of these three lakes comprising 42-72% of the population.

Coccoid blue-greens were also common components of the phytoplankton. Four coccoid blue-greens were important: *Anacystis incerta*, *Anacystis cyanea*,

TABLE 24. BREAKDOWN OF THE DISTRIBUTION OF THE DOMINANT PHYTOPLANKTON GROUPS AND SPECIES PRESENT WITHIN THE UPPER KISSIMMEE CHAIN OF LAKES DURING APRIL AND AUGUST 1982.

Class (Common Name)	Family and Major Groups	Dominant Species	Dominant Algae in Lakes
Cyanophyceae (Blue-green algae)	Chroococcaceae: (Coccoid blue-greens)	*Anacystis incerta* *Anacystis cyanea* *Anacystis montana* *Gomphosphaeria lacustris*	ST, C, H, K
Cyanophyceae (Blue-greens)	(a) Nostoceae: (filamentous blue-greens potential N_2 fixing species)	*Anabaena spiroides*	ST, C, H
	(b) Oscillatoriaceae: (filamentous blue-greens)	*Lyngbya contorta* *Lyngbya limnetica* *Schizothrix calcicola*	ST, C, H, K
Chlorophyceae (Green algae)	Scenedesmaceae: (non-filamentous green algae)	*Scenedesmus quadricauda*	ST, C, H, K
Bacillariophyceae (Diatoms)	Coscinodiscaceae: (circular or disc shaped diatoms)	*Melosira granulata*	ELT, NT
Dinophyceae ("armored" dinoflagellates)	Peridiniaceae: "armored", flagellated motile cells (dinoflagellates)	*Peridinium cinctum* *Peridinium* sp. #2	ELT

*Legend:
ELT = East Lake Toho, NT = North End, Lake Toho, ST = South End, Lake Toho, C = Cypress, H = Hatchineha; K = Kissimmee

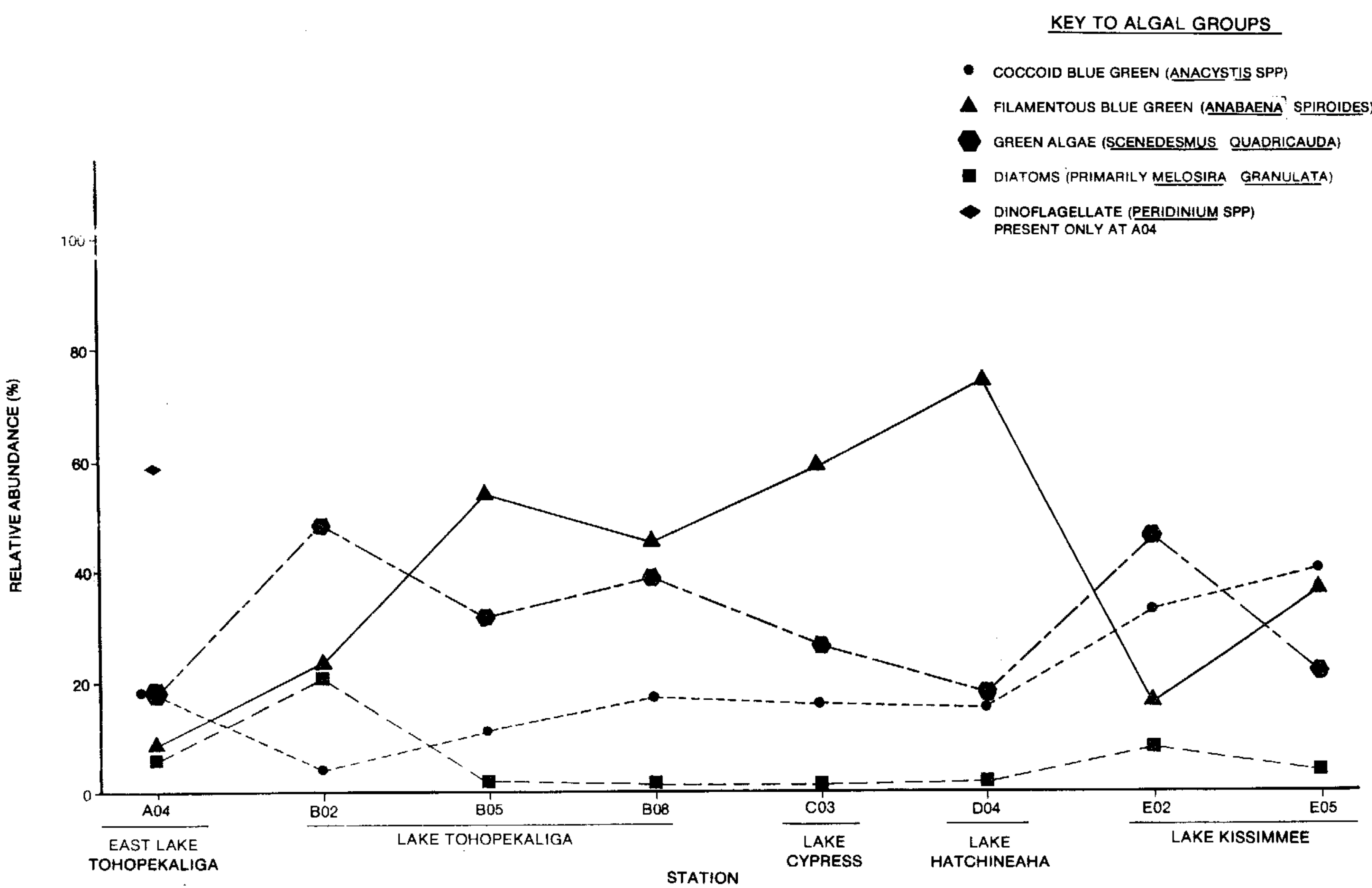


Fig. 26 RELATIVE ABUNDANCE OF MAJOR PHYTOPLANKTON - APRIL, 1982

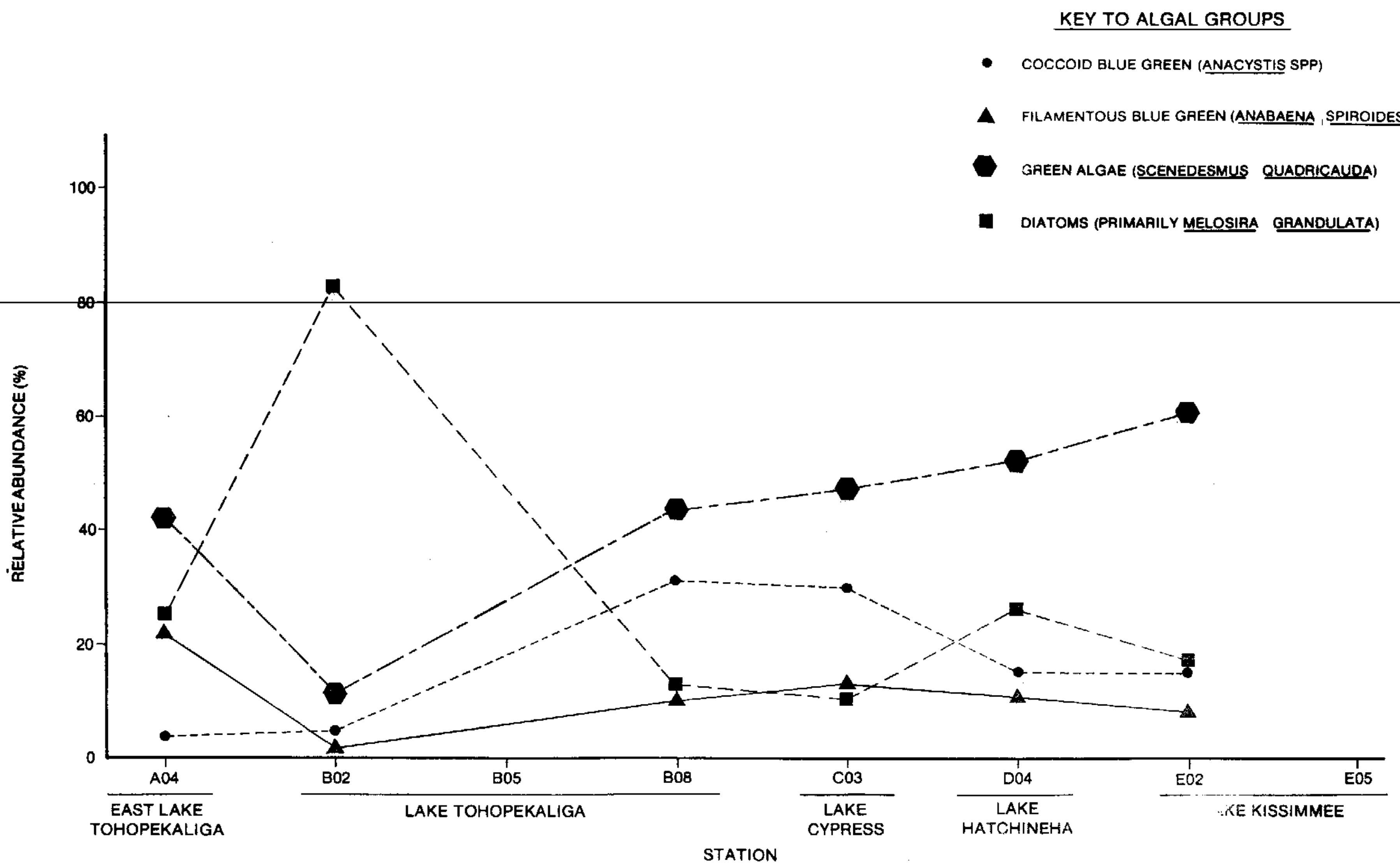


Fig. 29 RELATIVE ABUNDANCE OF MAJOR PHYTOPLANKTON AUGUST, 1982

Anacystis montana, and Gomphosphaeria lacustris. Of these four, Anacystis incerta was by far the most abundant.

In contrast, plankton in East Lake Tohopekaliga (Station A04) were dominated by two species of "armored" dinoflagellates, Peridinum spp. representing 57% of the population. Dinoflagellates (Dinophyceae) were only abundant at this site during April.

August, 1982

A shift in dominance was observed in samples collected in August 1982 as filamentous blue-greens (Anabaena sp.) were replaced by the green algae Scenedesmus quadricauda (Chlorophyceae). Scenedesmus spp. represented 43-60% of the total plankton in Lakes Cypress, Hatchineha, Kissimmee, and the south end of Tohopekaliga during August.

In comparison, diatoms (Bacillariophyceae) accounted for over 83% of the plankton at sites located in the north end of Lake Tohopekaliga. Melosira granulata was the dominant diatom species present during August. Diatom populations decreased southward within the chain of lakes during August and were replaced in importance by green algae (Scenedesmus) and coccoid blue-greens (Anacystis).

Estimates of Phytoplankton Cell Density and Volume

Low phytoplankton populations were consistently recorded from stations A04 (East Lake Tohopekaliga) and station B02 (north end of Tohopekaliga) where average cell densities ranged from 700 - 11,900 cells/ml. Highest cell densities occurred at station B09 (south end of Tohopekaliga) during August 1982 where cell densities reached 250,000 cells/ml during a Scenedesmus-Anacystis bloom. High cell densities and cell volumes were consistently recorded at sampling sites located in the south end of Lakes Tohopekaliga, Cypress, Hatchineha, and Kissimmee throughout 1982.

Phytoplankton Findings

Large populations (blooms) of the blue-greens, Anabaena spiroides, Anacystis incerta, Anacystis cyanaea, Gomphosphaeria lacustris, the green algae Scenedesmus quadricauda and the diatom Melosira granulata are reported to be indicative of highly eutrophic lakes (Palmer, 1960; Round, 1965).

Laboratory tests and field observations have shown that bloom forming blue-greens, (e.g. Anabaena and Anacystis species) and the green algae Scenedesmus quadricauda are generally inhibitory to other species of algae (Hutchinson, 1967). The presence of active inhibiting metabolites may explain why other phyla (planktonic greens, diatoms, chrysophytes, etc.) are present in only very low numbers at sites where blooms of these algae persist (i.e. the southern portion of the Kissimmee Chain of Lakes system).

Water Quality Comparison to other South Florida Lakes

Table 25 presents a mean comparison of major water chemistry parameters calculated for these five lakes and other lakes in central Florida. Differences in water chemistry data collected by two different groups may be more attributable to differences in sampling techniques, analytical methodologies, or period of study than actual differences in water chemistry. Although comparisons are worth discussion, they should not be regarded on an absolute basis.

Two general trends are obvious from Table 25:

(1) As a group, four of the five Upper Kissimmee lake chain show generally higher levels of chlorophyll a, major nutrients, conductivity, and chloride than the other lakes in this comparison. Specifically, Tohopekaliga demonstrated the highest total phosphorus and chlorophyll a, Lake Cypress the highest total nitrogen, and Lake Hatchineha the highest color of any of the lakes in the scan.

(2) The water quality data for the five lakes collected during this study demonstrates a general but substantial enrichment for most water chemistry indices over data collected by Canfield (1981). Specifically all five lakes of this study were characterized by higher total nitrogen, conductivity, and chlorides than comparative data. Total phosphorus demonstrated increased levels only for the lower three lakes. Chlorophyll a levels were lower than respective Canfield data for Lakes East Tohopekaliga, Tohopekaliga, and Cypress, but higher for Lakes Hatchineha and Kissimmee.

TABLE 25. GRAND MEAN WATER CHEMISTRY LAKE COMPARISONS FOR SELECTED PARAMETERS

Lake	# Sample	Cond. (mmhos/cm)	Cl mg/L	Total N mg/L	TPO_4 mg/L	CHL A mg/m^3	Color (units)	Secchi (meter)
Alligator 1/	9	105	22.5	0.57	.015	4.0	47	1.6
Arbuckle 1/	9	108	12.8	0.85	.049	19.0	112	0.8
Gentry 1/	9	94	20.9	0.61	.019	4.5	80	0.8
Hart 1/	9	90	18.1	1.11	.019	4.2	183	0.6
Lawne 1/	9	207	14.2	1.09	.172	18.3	62	0.9
Marian 1/	9	104	16.0	1.71	.074	61.7	51	0.6
Mary Jane 1/	9	84	17.5	1.25	.018	9.2	225	0.5
Rosalie 1/	9	83	12.5	0.66	.017	4.3	68	1.1
Tiger 1/	9	84	13.5	0.80	.043	16.1	67	0.6
Okeechobee 3/	24	702	90.9	2.45	.077	18.8	39	0.6
East Tohopekaliga 1/	9	96	20.8	0.64	.024	8.6	32	1.5
East Tohopekaliga 2/	36	145	22.2	0.72	.020	5.3	31	2.1
Tohopekaliga 1/	9	171	24.6	1.70	.368	69.6	53	0.4
Tohopekaliga 2/	79	268	30.9	2.31	.304	68.3	79	0.6
Cypress 1/	9	135	21.9	1.84	.131	77.9	57	0.4
Cypress 2/	18	244	27.4	2.33	.181	60.3	81	0.4
Hatchineha 1/	9	106	14.1	1.17	.046	17.4	129	0.6
Hatchineha 2/	24	208	20.7	2.26	.107	33.0	213	0.4
Kissimmee 1/	9	118	15.2	1.28	.042	29.2	53	0.7
Kissimmee 2/	36	204	20.7	1.90	.053	29.7	86	0.6

1/ extracted from Canfield (period of study 9/1/79 - 8/30/80)
2/ extracted from SFWMD (period of study 1/1/80-12/31/81)
3/ extracted from Federico et al (period of study 4/1/73 - 3/31/80)

TABLE 25. (Continued)

Lake	# Sample	pH	Alk meq/L	Hard mg/L $CaCO_3$	Na mg/L	K mg/L	SO_4 mg/L	SiO_2 mg/L	T Fe mg/L
Alligator 1/	9	5.66	.04	20.6	11.2	1.6	11.3	0.3	0.19
Arbuckle 1/	9	6.98	.20	36.1	7.6	2.5	27.6	2.6	0.15
Gentry 1/	9	6.09	.06	19.6	10.6	1.3	9.6	0.5	0.36
Hart 1/	9	5.87	.08	21.1	9.3	0.9	2.7	1.0	0.81
Lawne 1/	9	7.56	1.18	84.9	11.3	3.8	26.7	0.9	0.13
Marian 1/	9	7.83	.44	32.2	8.9	2.3	8.3	1.1	0.21
Mary Jane 1/	9	5.13	.06	18.6	9.0	0.7	11.7	1.3	1.13
Rosalie 1/	9	6.98	.18	24.6	6.9	1.3	12.7	2.1	0.63
Tiger 1/	9	7.33	.66	23.4	7.5	1.2	13.6	2.6	0.72
Okeechobee 3/	24	8.34	2.4	210.0	69.5	6.2	61.0	9.4	0.32
East Tohopekaliga 1/	9	6.05	.06	18.4	10.9	1.9	15.3	0.7	0.16
East Tohopekaliga 2/	36	6.54	.16	19.0	13.3	2.0	15.4	0.8	0.14
Tohopekaliga 1/	9	8.07	.78	36.7	18.4	3.1	13.9	3.0	0.24
Tohopekaliga 2/	79	8.18	.86	55.4	23.1	3.1	19.0	1.7	0.25
Cypress 1/	9	7.81	.44	35.9	13.2	2.1	12.8	0.5	0.33
Cypress 2/	18	8.32	.66	35.2	13.1	2.1	10.8	1.1	0.60
Hatchineha 1/	9	7.33	.48	39.4	7.9	1.5	11.2	3.8	0.30
Hatchineha 2/	24	7.31	.58	41.0	9.4	1.4	5.0	5.3	0.71
Kissimmee 1/	9	7.92	.44	37.2	10.3	1.6	11.7	1.6	0.23
Kissimmee 2/	36	8.05	.62	41.7	12.4	1.7	7.6	2.0	0.41

1/ extracted from Canfield (period of study 9/1/79 - 8/30/80)
2/ extracted from SFWMD (period of study 1/1/80-12/31/81)
3/ extracted from Federico et al (period of study 4/1/73 - 3/31/80)

(3) Lake Tohopekaliga demonstrates the highest mean total phosphorus comparative survey. Lakes Cypress, Hatchineha, and Kissimmee display progressive and respective improvements in water quality.

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APPENDIX A

WATER AND MATERIAL BUDGET CALCULATIONS

APPENDIX A

Water and Materials Budget Calculations

Surface Water: Surface water hydrologic measurements were made by either continuous recorders, discrete monthly flow measurements, or by recording the total hours of pumping at those sites where pumping capabilities exist.

At those surface water sites where continuous hydrology data was available, material loadings were calculated by combining the daily flow rates for a particular time period with the corresponding chemical data. Since the chemistry data was not collected daily, two chronologically successive chemistry data points were averaged to produce an estimated value for the time period between these two points. This average was then used in conjunction with the daily flow data within the time period to compute the daily loadings.

Where discrete monthly measurements were made, the total flow estimated for the month was combined with the monthly chemistry data to compute a total monthly load.

At the Judges Dairy and Partin's surface water pumping sites, the total number of hours pumped between two chronologically successive sampling dates were combined with the chemistry data at the endpoint of the time interval to produce a total monthly load.

Point Sources: The point source data includes the treatment plants Sand Lake Road, McLeod Road, Kissimmee Main, Kissimmee Interim, St. Cloud, and Camelot Manor. The data was supplied by the Florida Department of Environmental Regulation in monthly operating reports. All of the wastewater treatment plants monthly operating reports included daily flow data. However, most of the plants had only a limited number of chemistry values.

The Sand Lake Road and the McLeod Road wastewater treatment plants had the most complete chemical data sets. Material loadings for both of these plants were computed from the total monthly flow combined with the average of daily chemistry data for the month to compute a total monthly load.

The material loadings for the Kissimmee Main plant combined the total annual flow with the average annual chemistry data. In the case of nitrogen, the average concentration included an additional three month period beyond the annual endpoint (September, 1983). This was done to prevent overestimating the nitrogen budget based upon only two chemistry points which appeared to be excessive.

Material loadings for the Kissimmee Interim plant were computed by combining the total annual flow with the average concentration measured at two underdrains before discharge to Mill Slough. Since nitrite (NO_2) data was not available for this site, the total nitrogen load reflects only the total Kjeldahl nitrogen and nitrate data.

Total annual flow at the St. Cloud wastewater treatment plant was combined with the average chemical data available to compute the annual loading data for this point source. This site had the least amount of nutrient data available.

At the time of this writing, flow data was missing for three of the twelve months at the Camelot Manor wastewater treatment plant. Therefore, the average monthly flow was computed from the available data. This average was then used in place of each of the missing three months to produce an annual total flow. This total was then combined with the available average chemistry data.

Rainwater:

Due to the lack of rainfall chemistry data during months deficient in rain, monthly rainfall loadings could not be computed. Therefore, the total annual rainfall, based on the average of four stations for Lake Tohopekaliga and three stations for East Lake Tohopekaliga and adjusted for each lake area was combined with the average annual chemistry data to estimate the total annual load.

Groundwater: The groundwater seepage load to Lakes Tohopekaliga and East Lake Tohopekaliga was computed by totalling the average annual load from each of three and four piezometer wells, respectively. The total load for each site combined the total annual flow over the time period with the average annual concentration for that well. Although chemical measurements were not made on the groundwater supplied to East Lake Tohopekaliga's eastern side until the 1982-83 study year, the materials budget for this area of East Lake Tohopekaliga was computed for the 1981-82 study year with this more recent chemistry data and the former hydrology data.

APPENDIX B

WATER QUALITY SUMMARY OF EAST LAKE TOHOPEKALIGA TRIBUTARIES

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = BOGGY CREEK

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	19.9	7.5	6.59	138.	149.	2.3	6.3
ST. DEV.	5.3	1.8	.50	16.	46.	1.0	5.7
MIN. VAL.	9.4	5.3	5.52	113.	92.	.6	1.0
MAX. VAL.	26.1	11.4	7.49	169.	223.	3.9	13.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	15.5	18.8	31.1	8.55	2.38	10.38	2.11
ST. DEV.	2.4	4.0	2.2	.66	.28	.77	.30
MIN. VAL.	14.7	11.0	29.1	7.80	2.10	9.60	1.70
MAX. VAL.	22.2	25.0	34.1	9.20	2.70	11.30	2.43

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.095	42.000	.969	1.253	.400	.227	.100
ST. DEV.	.039						
MIN. VAL.	.065	42.000	.969	1.253	.400	.227	.100
MAX. VAL.	.140	42.000	.969	1.253	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	11	12	12
AVERAGE	.31	1.06	.99	.07	.032	.006	.03
ST. DEV.	.13	.31	.31	.03	.031	.005	.02
MIN. VAL.	.17	.70	.60	.02	.004	.004	.01
MAX. VAL.	.46	1.71	1.58	.13	.115	.020	.06

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.129	.098	16.3	6.5	9.0
ST. DEV.	.045	.040	6.2	1.4	3.7
MIN. VAL.	.064	.041	5.8	4.6	5.4
MAX. VAL.	.222	.187	28.7	8.0	13.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = DAKOTA AVE. DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	[illegible]	[illegible]
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	21.5	4.0	6.24	218.	50.	2.6	[illegible]
ST. DEV.	4.9	1.9	.46	34.	43.	2.0	[illegible]
MIN. VAL.	12.2	1.4	5.65	167.	4.	.3	[illegible]
MAX. VAL.	27.4	6.8	7.04	276.	129.	7.1	[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	7.6	29.0	65.5	19.20	4.25	10.85	1.05
ST. DEV.	4.4	13.4	6.6	2.81	.26	1.17	.76
MIN. VAL.	2.9	9.5	59.9	16.40	4.00	10.20	.60
MAX. VAL.	16.0	53.0	75.4	23.10	4.00	12.60	2.30

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.148	17.000	.691	.277	.400	.227	.100
ST. DEV.	.042						
MIN. VAL.	.114	17.000	.691	.277	.400	.227	.100
MAX. VAL.	.200	17.000	.691	.277	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	12	12	12
AVERAGE	.50	.76	.66	.12	.041	.005	.06
ST. DEV.	.37	.59	.48	.17	.067	.003	.17
MIN. VAL.	.06	.10	.10	.01	.004	.004	.01
MAX. VAL.	.92	2.23	1.64	.59	.210	.013	.59

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.056	.026	13.7	8.8	23.2
ST. DEV.	.091	.049	5.5	1.8	2.5
MIN. VAL.	.011	.002	4.7	6.9	20.9
MAX. VAL.	.325	.160	25.3	10.5	26.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER RANGE OF VALUES UNITS

DATE 10/ 1/81 - 9/31/82 MO/DA/YR
SAMPLE 2. 2. TYPE

STATIONS EAST LAKE TOHOPEKALIGA GROUNDWATER

	TEMP CENT	PH	SP COND UMHOS/CM	COLOR UNITS	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L
NUM. VALS.	10	13	13	9	13	7	7
AVERAGE	26.3	5.46	226.	119.	32.2	39.7	10.73
ST. DEV.	2.3	.96	85.	94.	25.0	24.7	9.78
MIN. VAL.	23.1	3.98	96.	3.	5.0	8.3	2.00
MAX. VAL.	29.0	7.15	333.	243.	76.0	72.6	25.20

	MG MG/L	NA MG/L	K MG/L	TDISS FE MG/L	TDISS N MG N/L	DORG.N MG N/L	NOX+NH4 MG N/L
NUM. VALS.	7	7	7	6	13	13	13
AVERAGE	3.13	19.56	1.56	2.11	1.91	1.00	.91
ST. DEV.	1.63	11.78	1.27	2.55	1.07	1.05	.78
MIN. VAL.	.80	8.60	.38	.28	.48	.24	.14
MAX. VAL.	5.30	35.20	3.30	6.21	4.30	4.14	2.07

	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L	TDPO4 MG P/L	DORG PO4 MG P/L	OPO4 MG P/L	CL MG/L
NUM. VALS.	13	13	13	13	13	13	13
AVERAGE	.024	.008	.88	.036	.017	.021	22.0
ST. DEV.	.030	.007	.75	.019	.010	.013	12.6
MIN. VAL.	.004	.004	.10	.008	.010	.004	5.8
MAX. VAL.	.081	.030	2.00	.061	.039	.043	46.4

	SIO2 MG/L
NUM. VALS.	3
AVERAGE	14.3
ST. DEV.	8.6
MIN. VAL.	4.5
MAX. VAL.	20.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = JIM BRANCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	[illegible]	[illegible]
NUM. VALS.	10	9	12	11	12	12	
AVERAGE	20.0	3.3	4.45	106.	307.	3.4	[illegible]
ST. DEV.	5.1	1.6	.70	28.	119.	4.2	[illegible]
MIN. VAL.	11.2	1.2	3.55	61.	111.	.4	[illegible]
MAX. VAL.	25.8	6.5	6.06	158.	575.	15.6	[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	26.3	5.5	12.6	2.43	1.65	9.35	.39
ST. DEV.	7.3	1.2	3.1	.53	.45	2.91	.14
MIN. VAL.	17.1	5.0	8.6	1.80	1.00	6.10	.26
MAX. VAL.	42.5	9.0	16.0	3.10	2.00	12.00	.58

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.095	32.000	1.639	1.958	.400	18.022	.100
ST. DEV.	.033						
MIN. VAL.	.058	32.000	1.639	1.958	.400	18.022	.100
MAX. VAL.	.133	32.000	1.639	1.958	.400	18.022	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	5	12	12
AVERAGE	.79	1.45	1.40	.05	.005	.006	.04
ST. DEV.	.30	.50	.49	.04	.003	.004	.03
MIN. VAL.	.42	.45	.43	.01	.004	.004	.01
MAX. VAL.	1.15	2.36	2.32	.11	.013	.014	.10

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.115	.067	17.4	4.6	10.7
ST. DEV.	.067	.051	9.7	2.1	2.0
MIN. VAL.	.031	.008	4.0	2.9	9.5
MAX. VAL.	.257	.160	35.0	7.6	13.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = LAKE HART AT S-62

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	23.7	7.4	5.53	162.	147.	4.5	7.5
ST. DEV.	5.7	1.1	.50	23.	66.	1.5	3.5
MIN. VAL.	13.7	5.8	4.73	119.	87.	1.7	4.0
MAX. VAL.	30.7	9.0	6.52	199.	280.	7.7	11.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	18.0	9.7	32.3	7.50	3.30	12.76	1.36
ST. DEV.	5.1	9.3	3.8	.73	.50	1.58	.10
MIN. VAL.	14.9	5.0	26.9	6.50	2.60	10.60	1.27
MAX. VAL.	24.5	38.5	35.7	8.20	3.70	14.60	1.50

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.074	33.000	1.500	1.317	.400	5.627	.100
ST. DEV.	.030						
MIN. VAL.	.048	33.000	1.500	1.317	.400	5.627	.100
MAX. VAL.	.126	33.000	1.500	1.317	.400	5.627	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	12	12	12
AVERAGE	.55	1.51	1.35	.17	.125	.007	.04
ST. DEV.	.21	.55	.54	.05	.049	.005	.02
MIN. VAL.	.40	.37	.22	.08	.043	.004	.01
MAX. VAL.	.85	2.56	2.38	.23	.186	.021	.09

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.034	.005	20.3	1.8	17.3
ST. DEV.	.018	.005	6.3	.8	2.0
MIN. VAL.	.018	.002	11.8	.9	15.3
MAX. VAL.	.085	.020	34.6	2.7	19.2

APPENDIX C

WATER QUALITY SUMMARY OF LAKE TOHOPEKALIGA TRIBUTARIES

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81	- 9/31/82	MO/DA/YR
DEPTH	0.0	- 0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = EAST KISSIMMEE CITY DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	21.9	3.1	6.87	285.	92.	7.6	9.3
ST. DEV.	5.9	2.0	.54	51.	75.	4.8	5.1
MIN. VAL.	11.0	1.2	5.68	154.	30.	1.4	4.0
MAX. VAL.	29.3	8.2	7.97	365.	312.	14.1	16.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	14.5	77.1	86.1	29.50	3.03	13.30	2.28
ST. DEV.	3.0	22.1	26.6	10.11	.45	1.63	.23
MIN. VAL.	9.6	26.0	48.8	15.60	2.40	12.20	2.00
MAX. VAL.	20.1	104.5	108.2	38.40	3.40	15.70	2.52

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.230	14.000	.637	1.253	.400	.227	.100
ST. DEV.	.031						
MIN. VAL.	.196	14.000	.637	1.253	.400	.227	.100
MAX. VAL.	.270	14.000	.637	1.253	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	11	11	12
AVERAGE	1.00	1.12	.99	.14	.045	.009	.09
ST. DEV.	.74	.47	.50	.09	.089	.014	.06
MIN. VAL.	.51	.22	.10	.01	.004	.004	.01
MAX. VAL.	2.10	1.99	1.65	.33	.312	.050	.21

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.290	.167	17.9	6.9	10.2
ST. DEV.	.154	.100	5.9	2.8	2.7
MIN. VAL.	.037	.063	6.9	6.3	7.2
MAX. VAL.	.899	.457	26.2	11.8	13.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = JOHNSON DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	[illegible]
NUM. VALS.	5	5	5	5	5	5	2
AVERAGE	23.5	3.6	4.25	253.	977.	6.2	3.[illegible]
ST. DEV.	4.7	1.6	.73	195.	4[illegible].	8.5	[illegible]
MIN. VAL.	17.7	1.6	3.74	110.	4[illegible].	1.6	[illegible]
MAX. VAL.	29.3	6.0	5.50	586.	16[illegible].	22.0	

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	4	5	2	2	2	2	2
AVERAGE	138.2	8.5	106.3	27.50	9.15	19.45	1.22
ST. DEV.	81.3	4.6	103.6	26.30	9.26	12.80	.31
MIN. VAL.	45.5	5.0	32.9	8.90	2.60	10.40	1.00
MAX. VAL.	222.4	14.5	179.7	46.10	15.70	28.50	1.44

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	2	0	0	0	0	0	0
AVERAGE	.177						
ST. DEV.	.004						
MIN. VAL.	.174						
MAX. VAL.	.180						

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	2	5	5	5	5	5	5
AVERAGE	2.29	5.60	4.76	.84	.016	.032	.80
ST. DEV.	1.09	2.57	1.60	.81	.008	.015	.80
MIN. VAL.	1.52	2.88	2.84	.04	.004	.015	.01
MAX. VAL.	3.06	8.38	6.87	1.98	.026	.056	1.92

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	5	5	5	2	2
AVERAGE	.352	.206	25.7	19.9	74.5
ST. DEV.	.110	.100	13.6	15.5	68.6
MIN. VAL.	.201	.093	12.6	8.9	26.0
MAX. VAL.	.462	.342	44.5	30.8	123.0

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = JUDGES DAIRY

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	8	8	8	8	8	8	3
AVERAGE	22.8	3.5	6.50	580.	271.	15.8	51.0
ST. DEV.	7.2	1.8	.44	90.	83.	12.7	55.3
MIN. VAL.	10.2	1.2	5.60	449.	200.	2.8	4.0
MAX. VAL.	31.3	6.7	6.97	717.	462.	36.0	112.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	7	8	3	3	3	3	3
AVERAGE	51.2	93.1	135.9	35.97	11.20	23.60	16.55
ST. DEV.	16.1	41.6	11.1	4.40	.62	.75	3.05
MIN. VAL.	30.8	41.0	124.3	31.00	10.50	23.10	13.70
MAX. VAL.	79.5	162.0	146.5	39.40	11.70	24.60	19.76

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	3	1	1	1	1	1	1
AVERAGE	.211	77.000	1.344	2.162	.400	2.165	.200
ST. DEV.	.036						
MIN. VAL.	.180	77.000	1.344	2.162	.400	2.165	.200
MAX. VAL.	.250	77.000	1.344	2.162	.400	2.165	.200

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	3	8	8	8	8	8	8
AVERAGE	1.07	12.11	4.93	7.16	.059	.101	7.02
ST. DEV.	.21	5.19	1.91	4.01	.069	.137	4.02
MIN. VAL.	.86	5.33	2.66	2.41	.004	.006	2.05
MAX. VAL.	1.28	19.82	7.41	12.41	.192	.395	11.99

	TPO4 MG P/L	ORPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	8	8	8	3	3
AVERAGE	3.836	3.511	51.7	12.6	51.1
ST. DEV.	2.457	2.435	7.1	8.7	29.5
MIN. VAL.	1.253	.663	43.8	3.0	20.9
MAX. VAL.	6.660	6.293	64.4	20.0	79.9

ANNUAL AVERAGE WATER QUALITY

PARAMETER RANGE OF VALUES UNITS

DATE 10/ 1/81 - 9/31/82 MO/DA/YR
SAMPLE 2. 2. TYPE

STATIONS LAKE TOHOPEKALIGA GROUNDWATER

	TEMP CENT	PH	SP COND UMHOS/CM	COLOR UNITS	ALKCACO3 MG/L	HARDNESS MG/LCACO	[illegible]
NUM. VALS.	8	11	11	8	11	6	[illegible]
AVERAGE	25.1	5.86	233.	40.	49.5	78.5	[illegible]
ST. DEV.	2.7	1.22	166.	26.	53.3	100.2	[illegible]
MIN. VAL.	22.1	4.14	78.	17.	5.0	12.4	[illegible]
MAX. VAL.	28.9	7.83	497.	84.	138.0	248.6	[illegible]

	MG MG/L	NA MG/L	K MG/L	TDISS FE MG/L	TDISS N MG N/L	DORG.N MG N/L	NOX+NH4 MG N/L
NUM. VALS.	6	6	6	6	11	11	11
AVERAGE	2.40	9.53	1.48	.42	5.95	.60	5.34
ST. DEV.	.99	4.02	1.65	.74	6.41	.37	6.35
MIN. VAL.	1.20	5.40	.16	.02	.22	.01	.06
MAX. VAL.	3.90	15.30	3.80	1.88	18.89	1.16	18.70

	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L	TDPO4 MG P/L	DORG PO4 MG P/L	OPO4 MG P/L	CL MG/L
NUM. VALS.	11	11	11	11	11	11	11
AVERAGE	5.293	.006	.04	.095	.043	.052	11.1
ST. DEV.	6.369	.004	.03	.035	.020	.040	8.1
MIN. VAL.	.004	.004	.01	.038	.010	.007	.7
MAX. VAL.	18.678	.016	.10	.150	.084	.122	28.3

	SIO2 MG/L
NUM. VALS.	3
AVERAGE	10.7
ST. DEV.	.9
MIN. VAL.	9.6
MAX. VAL.	11.2

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = MILL SLOUGH CODE

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	21.2	6.3	6.45	164.	352.	4.3	12.3
ST. DEV.	5.3	1.5	.60	69.	132.	2.4	7.9
MIN. VAL.	11.7	4.9	5.28	74.	143.	1.7	4.0
MAX. VAL.	27.4	10.0	7.42	334.	585.	10.2	22.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	26.2	29.1	25.9	7.43	1.78	19.43	8.79
ST. DEV.	9.3	25.7	5.8	1.77	.54	14.01	9.99
MIN. VAL.	14.3	12.0	17.3	5.10	1.10	7.30	1.81
MAX. VAL.	43.7	104.5	30.1	9.40	2.30	39.60	23.60

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.103	119.000	1.028	3.559	.400	.656	.100
ST. DEV.	.032						
MIN. VAL.	.076	119.000	1.028	3.559	.400	.656	.100
MAX. VAL.	.146	119.000	1.028	3.559	.400	.656	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	12	12	12
AVERAGE	.76	1.75	1.66	.10	.057	.013	.03
ST. DEV.	.26	.71	.73	.05	.046	.007	.02
MIN. VAL.	.39	.81	.67	.03	.004	.004	.01
MAX. VAL.	.95	3.03	2.94	.18	.138	.031	.05

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.195	.127	15.6	6.7	12.3
ST. DEV.	.058	.054	7.1	2.6	5.0
MIN. VAL.	.114	.045	5.9	5.3	7.3
MAX. VAL.	.333	.294	34.4	10.8	19.2

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81	- 9/31/82	MO/DA/YR
DEPTH	0.0	- 0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = NORTH PARTIN DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	[illegible]
NUM. VALS.	12	12	12	11	11	11	[illegible]
AVERAGE	22.6	5.0	5.52	142.	2[illegible].	4.5	9.6
ST. DEV.	3.6	1.6	.80	31.	130.	3.8	6.2
MIN. VAL.	15.5	1.9	3.87	96.	119.	1.8	1.0
MAX. VAL.	27.5	7.6	6.89	192.	403.	14.7	20.[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	10	11	4	4	4	4	4
AVERAGE	28.8	8.3	30.1	6.53	3.35	12.25	1.18
ST. DEV.	9.2	4.0	7.4	1.24	1.07	1.43	.34
MIN. VAL.	15.7	5.0	21.2	5.20	2.00	10.20	.80
MAX. VAL.	41.4	17.5	39.2	8.10	4.00	13.50	1.00

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.085	21.000	.418	1.189	.400	.227	.100
ST. DEV.	.038						
MIN. VAL.	.056	21.000	.418	1.189	.400	.227	.100
MAX. VAL.	.137	21.000	.418	1.189	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	11	11	11	7	11	11
AVERAGE	1.14	1.60	1.53	.07	.036	.006	.03
ST. DEV.	.88	.47	.51	.06	.051	.004	.02
MIN. VAL.	.24	.67	.51	.02	.004	.004	.01
MAX. VAL.	2.30	2.35	2.33	.17	.135	.014	.09

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	11	11	11	4	4
AVERAGE	.067	.013	19.2	6.5	16.3
ST. DEV.	.041	.007	6.5	4.0	1.3
MIN. VAL.	.031	.004	4.1	.5	14.6
MAX. VAL.	.180	.023	31.3	9.2	17.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER RANGE OF VALUES UNITS

DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = OVERSTREET DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	5	5	5	5	5	5	2
AVERAGE	26.4	3.1	5.36	165.	383.	4.9	10.5
ST. DEV.	2.2	1.4	.66	31.	168.	1.7	6.4
MIN. VAL.	22.7	1.9	4.69	121.	240.	3.1	6.0
MAX. VAL.	28.6	4.8	6.44	208.	670.	6.7	15.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	3	5	2	2	2	2	2
AVERAGE	29.0	10.8	26.2	6.10	2.65	11.60	1.37
ST. DEV.	1.6	5.5	3.0	.65	.21	.99	.52
MIN. VAL.	27.7	5.0	24.0	5.50	2.50	10.90	1.00
MAX. VAL.	30.8	17.5	28.3	6.70	2.80	12.30	1.74

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	2	0	0	0	0	0	0
AVERAGE	.141						
ST. DEV.	.044						
MIN. VAL.	.110						
MAX. VAL.	.172						

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	2	5	5	5	4	5	5
AVERAGE	1.98	2.63	2.40	.22	.015	.013	.20
ST. DEV.	.35	1.54	1.27	.29	.021	.011	.25
MIN. VAL.	1.73	1.64	1.56	.06	.004	.006	.05
MAX. VAL.	2.23	5.35	4.62	.73	.046	.032	.65

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	5	5	5	2	2
AVERAGE	.137	.054	20.1	6.5	10.4
ST. DEV.	.137	.060	4.3	1.8	1.3
MIN. VAL.	.046	.015	15.4	5.2	9.5
MAX. VAL.	.379	.198	27.0	7.8	11.3

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = PARTIN CANAL

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	[illegible]
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	21.2	3.4	6.29	237.	17[illegible].	3.4	19.[illegible]
ST. DEV.	5.5	1.9	.62	53.	67.	2.9	21.[illegible]
MIN. VAL.	10.6	1.0	5.22	127.	74.	.8	5.0
MAX. VAL.	30.4	7.1	7.59	312.	274.	11.0	52.[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	[illegible] MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	24.7	36.2	48.2	13.48	3.35	18.90	3.20
ST. DEV.	6.6	15.2	17.0	5.34	.99	3.66	1.34
MIN. VAL.	16.2	15.0	27.4	7.50	2.10	14.20	2.06
MAX. VAL.	36.2	64.0	67.6	19.80	4.40	23.10	4.92

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.206	14.000	.354	2.214	.400	.227	.100
ST. DEV.	.066						
MIN. VAL.	.156	14.000	.354	2.214	.400	.227	.100
MAX. VAL.	.305	14.000	.354	2.214	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	11	12	12
AVERAGE	.70	1.67	1.60	.07	.025	.006	.05
ST. DEV.	.29	.64	.64	.04	.021	.002	.04
MIN. VAL.	.39	.94	.90	.02	.004	.004	.01
MAX. VAL.	.95	3.17	3.13	.16	.076	.010	.14

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.463	.277	28.5	11.0	14.6
ST. DEV.	.297	.206	6.7	5.3	5.9
MIN. VAL.	.170	.055	17.4	6.6	6.6
MAX. VAL.	1.221	.755	38.7	18.0	20.6

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = PARTIN PUMP

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	10	10	10	9	10	10	4
AVERAGE	22.9	4.8	5.98	327.	266.	10.3	10.8
ST. DEV.	7.3	2.2	.72	85.	120.	12.6	10.1
MIN. VAL.	11.0	1.5	5.13	214.	109.	1.4	1.0
MAX. VAL.	33.1	7.9	7.47	473.	444.	42.0	25.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	9	10	4	4	4	4	4
AVERAGE	37.9	18.7	99.4	24.45	9.33	20.10	2.75
ST. DEV.	8.9	7.5	27.2	6.27	2.99	5.62	1.82
MIN. VAL.	27.0	9.5	67.7	17.40	5.90	15.30	.99
MAX. VAL.	55.1	31.0	132.5	31.30	13.20	28.20	5.30

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.183	100.000	.818	2.054	.400	3.939	.200
ST. DEV.	.020						
MIN. VAL.	.165	100.000	.818	2.054	.400	3.939	.200
MAX. VAL.	.210	100.000	.818	2.054	.400	3.939	.200

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	10	10	10	9	10	10
AVERAGE	.91	3.39	3.18	.21	.017	.009	.19
ST. DEV.	.81	1.03	1.03	.22	.030	.005	.21
MIN. VAL.	.15	2.14	1.98	.01	.004	.004	.01
MAX. VAL.	1.98	5.04	4.63	.66	.095	.021	.66

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	10	10	10	4	4
AVERAGE	.056	.004	30.4	4.6	61.8
ST. DEV.	.028	0.000	7.9	3.0	38.1
MIN. VAL.	.021	.004	20.5	1.6	20.9
MAX. VAL.	.099	.004	44.0	6.7	104.0

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = PLEASANT HILL ESTATES

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	[illegible]	[illegible]
NUM. VALS.	5	5	5	5	5	6	[illegible]
AVERAGE	18.8	4.9	6.70	269.	322.	3.0	[illegible]
ST. DEV.	1.7	1.1	.62	34.	11[illegible].	1.5	[illegible]
MIN. VAL.	16.6	3.7	6.09	237.	167.	.8	1.0
MAX. VAL.	21.0	6.1	7.74	315.	43[illegible].	5.1	14.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	5	5	2	2	2	2	2
AVERAGE	41.5	49.5	84.4	25.25	5.20	18.80	2.66
ST. DEV.	15.4	17.4	29.9	12.66	.42	3.54	1.33
MIN. VAL.	22.9	34.0	63.3	16.30	4.90	16.30	1.72
MAX. VAL.	62.7	76.0	105.5	34.20	5.50	21.30	3.60

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	2	1	1	1	1	1	1
AVERAGE	.162	40.000	.725	4.135	.400	1.184	.100
ST. DEV.	.040						
MIN. VAL.	.134	40.000	.725	4.135	.400	1.184	.100
MAX. VAL.	.190	40.000	.725	4.135	.400	1.184	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	2	5	5	5	4	5	5
AVERAGE	.70	3.49	3.45	.04	.008	.009	.02
ST. DEV.	.24	1.45	1.44	.02	.009	.004	.01
MIN. VAL.	.53	1.92	1.90	.01	.004	.004	.01
MAX. VAL.	.87	5.57	5.51	.06	.021	.014	.04

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	5	5	5	2	2
AVERAGE	.147	.047	33.4	4.5	16.4
ST. DEV.	.077	.030	9.7	2.7	.2
MIN. VAL.	.085	.009	24.5	2.6	16.2
MAX. VAL.	.276	.091	46.0	6.4	16.5

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = RAINFALL

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	0	0	0	0	2	5	0
AVERAGE					6.	2.8	
ST. DEV.					6.	2.3	
MIN. VAL.					2.	.4	
MAX. VAL.					10.	5.3	

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	1	10	0	0	0	0	0
AVERAGE	25.5	6.3					
ST. DEV.		3.0					
MIN. VAL.	25.5	5.0					
MAX. VAL.	25.5	14.5					

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	0	0	0	0	0	0	0
AVERAGE							
ST. DEV.							
MIN. VAL.							
MAX. VAL.							

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	0	11	11	11	11	11	11
AVERAGE		1.42	.81	.62	.311	.007	.30
ST. DEV.		.65	.45	.30	.107	.004	.25
MIN. VAL.		.50	.10	.34	.165	.004	.08
MAX. VAL.		2.38	1.65	1.30	.574	.015	.71

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	11	11	11	0	1
AVERAGE	.066	.051	4.2		5.0
ST. DEV.	.062	.037	3.2		
MIN. VAL.	.042	.024	.3		5.0
MAX. VAL.	.250	.143	12.3		5.0

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = SHINGLE CREEK (EAST)

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB [illegible]	[illegible]
NUM. VALS.	11	11	11	11	12	12	[illegible]
AVERAGE	21.7	8.9	6.91	282.	22[illegible].	2.4	[illegible]
ST. DEV.	5.0	1.6	.60	42.	[illegible]	.9	[illegible]
MIN. VAL.	13.2	5.1	5.19	197.	7[illegible].	.6	[illegible]
MAX. VAL.	27.6	9.5	8.20	335.	38[illegible].	3.9	[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	24.0	41.8	71.2	20.88	4.[illegible]	23.70	3.43
ST. DEV.	5.6	17.4	17.5	4.64	1.33	6.65	.61
MIN. VAL.	15.6	5.0	52.9	15.60	3.40	14.40	2.59
MAX. VAL.	34.5	72.5	91.0	26.40	6.10	30.10	4.49

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.276	70.000	.733	1.798	.400	.227	.100
ST. DEV.	.065						
MIN. VAL.	.182	70.000	.733	1.798	.400	.227	.100
MAX. VAL.	.330	70.000	.733	1.798	.400	.227	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	12	12	12
AVERAGE	.31	1.85	1.57	.29	.231	.021	.04
ST. DEV.	.12	.75	.66	.26	.235	.042	.02
MIN. VAL.	.19	.97	.89	.08	.046	.004	.01
MAX. VAL.	.44	3.56	3.32	.79	.730	.153	.07

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.550	.451	27.7	7.1	23.4
ST. DEV.	.206	.186	7.3	1.1	9.2
MIN. VAL.	.250	.199	16.6	6.0	13.3
MAX. VAL.	.941	.855	42.2	8.3	32.0

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = SHINGLE CREEK (WEST)

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	5	5	5	5	5	5	2
AVERAGE	25.9	6.2	6.67	267.	185.	3.5	6.5
ST. DEV.	2.9	.9	.57	78.	136.	1.4	3.5
MIN. VAL.	20.9	5.3	5.90	176.	41.	1.9	4.0
MAX. VAL.	27.9	7.4	7.25	354.	344.	5.3	9.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	4	5	2	2	2	2	2
AVERAGE	22.6	42.4	56.5	16.85	3.50	19.95	2.81
ST. DEV.	8.8	23.9	4.0	1.34	.14	7.57	.28
MIN. VAL.	12.5	16.0	53.7	15.90	3.40	14.60	2.61
MAX. VAL.	31.1	75.0	59.3	17.80	3.60	25.30	3.00

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	2	0	0	0	0	0	0
AVERAGE	.262						
ST. DEV.	.111						
MIN. VAL.	.183						
MAX. VAL.	.340						

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	2	5	5	5	5	5	5
AVERAGE	.35	1.46	1.34	.12	.065	.008	.05
ST. DEV.	.21	.34	.34	.06	.041	.004	.01
MIN. VAL.	.20	.98	.86	.04	.004	.004	.04
MAX. VAL.	.50	1.93	1.77	.18	.099	.012	.07

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	5	5	5	2	2
AVERAGE	.396	.355	21.4	8.1	18.1
ST. DEV.	.174	.171	6.3	2.4	4.9
MIN. VAL.	.261	.206	14.0	6.4	14.6
MAX. VAL.	.662	.550	29.8	9.8	21.5

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = SOUTH PARTIN DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.S.
NUM. VALS.	10	10	10	9	10	10	3
AVERAGE	21.7	4.0	5.76	164.	39[illegible].	6.2	2.[illegible]
ST. DEV.	4.7	1.7	1.47	87.	207.	4.9	1.5
MIN. VAL.	13.2	1.6	3.76	91.	17[illegible].	2.1	[illegible]
MAX. VAL.	27.9	7.1	8.13	329.	90[illegible].	19.0	4.[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	9	10	3	3	3	3	3
AVERAGE	59.5	42.6	54.9	16.80	3.15	16.67	1.95
ST. DEV.	26.5	54.4	54.4	20.56	1.[illegible]	1.29	1.03
MIN. VAL.	19.4	5.0	16.6	3.50	1.90	15.20	.80
MAX. VAL.	91.0	154.5	117.2	40.50	3.90	17.60	2.60

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	3	1	1	1	1	1	1
AVERAGE	.063	140.000	.679	1.413	.400	5.770	.100
ST. DEV.	.021						
MIN. VAL.	.040	140.000	.679	1.413	.400	5.770	.100
MAX. VAL.	.082	140.000	.679	1.413	.400	5.770	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	3	10	10	10	6	10	10
AVERAGE	1.82	2.63	2.06	.57	.040	.017	.54
ST. DEV.	1.20	1.20	.68	1.09	.056	.010	1.06
MIN. VAL.	.70	1.15	1.11	.04	.004	.007	.03
MAX. VAL.	3.12	5.48	3.42	3.56	.147	.039	3.46

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	10	10	10	3	3
AVERAGE	.167	.062	22.9	9.0	16.6
ST. DEV.	.089	.046	9.0	2.2	7.5
MIN. VAL.	.059	.014	4.1	6.9	11.0
MAX. VAL.	.325	.142	33.8	11.3	24.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION = ST. CLOUD CANAL

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	10	10	10	10	11	11	4
AVERAGE	23.0	5.8	6.78	311.	63.	2.3	7.8
ST. DEV.	5.3	1.7	.75	91.	21.	1.0	8.1
MIN. VAL.	14.6	3.6	5.62	148.	13.	1.0	1.0
MAX. VAL.	31.0	8.9	8.05	420.	95.	4.3	19.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	10	11	4	4	4	4	4
AVERAGE	13.4	36.1	62.4	17.03	4.83	22.48	3.84
ST. DEV.	5.3	16.3	29.9	9.60	1.45	9.80	1.71
MIN. VAL.	.1	12.5	20.7	3.50	2.90	11.00	1.87
MAX. VAL.	20.1	62.0	87.6	25.20	6.00	32.00	5.60

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.191	17.000	.607	1.285	.400	.227	.300
ST. DEV.	.012						
MIN. VAL.	.175	17.000	.607	1.285	.400	.227	.300
MAX. VAL.	.205	17.000	.607	1.285	.400	.227	.300

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	11	11	11	11	11	11
AVERAGE	.26	3.63	1.41	2.22	1.184	.042	1.00
ST. DEV.	.19	2.54	.86	2.24	1.069	.051	1.27
MIN. VAL.	.09	.65	.61	.04	.006	.004	.01
MAX. VAL.	.50	7.20	3.51	5.55	2.960	.138	3.35

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	11	11	11	4	4
AVERAGE	.250	.195	31.0	5.3	23.1
ST. DEV.	.191	.172	9.5	2.9	13.0
MIN. VAL.	.050	.006	20.1	1.4	5.0
MAX. VAL.	.605	.493	51.2	8.3	35.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES			UNITS
DATE	10/ 1/81	-	9/31/82	MO/DA/YR
DEPTH	0.0	-	0.0	METERS
SAMPLE	0.		1.	TYPE

STATION * ST. CLOUD CANAL AT S-59

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.[illegible] [illegible]
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	23.4	6.3	6.45	153.	40.	1.6	[illegible]
ST. DEV.	5.6	1.3	.83	21.	21.	1.3	
MIN. VAL.	13.1	4.5	5.03	115.	15.	.4	
MAX. VAL.	30.1	8.0	7.65	194.	75.	5.5	[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO3	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	8.4	14.4	24.6	4.40	3.30	14.00	1.87
ST. DEV.	2.3	9.5	3.7	.91	.41	1.30	.26
MIN. VAL.	5.6	6.0	19.1	3.20	2.70	12.00	1.50
MAX. VAL.	13.6	36.0	27.5	5.40	3.60	15.00	2.10

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.124	36.000	1.449	1.670	.400	1.109	.100
ST. DEV.	.031						
MIN. VAL.	.093	36.000	1.449	1.670	.400	1.109	.100
MAX. VAL.	.151	36.000	1.449	1.670	.400	1.109	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	12	12	12
AVERAGE	.13	.80	.76	.04	.012	.005	.03
ST. DEV.	.09	.30	.29	.02	.016	.003	.02
MIN. VAL.	.06	.10	.10	.01	.004	.004	.01
MAX. VAL.	.27	1.20	1.15	.08	.054	.012	.06

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	.031	.005	21.8	.8	10.5
ST. DEV.	.015	.001	6.2	.4	3.2
MIN. VAL.	.013	.003	12.4	.4	7.2
MAX. VAL.	.069	.008	36.5	1.4	15.7

ANNUAL AVERAGE WATER QUALITY

PARAMETER   RANGE OF VALUES   UNITS

DATE   10/ 1/81 - 9/31/82 MO/DA/YR
DEPTH   0.0 - 0.0 METERS
SAMPLE   0.   1. TYPE

STATION = WEST KISSIMMEE CITY DITCH

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T.SUS.SD MG/L
NUM. VALS.	12	12	12	11	12	12	4
AVERAGE	24.5	3.1	7.08	527.	107.	9.1	9.3
ST. DEV.	5.3	1.6	.51	158.	64.	6.8	6.2
MIN. VAL.	16.4	.9	6.05	230.	48.	3.8	1.0
MAX. VAL.	32.4	5.8	8.11	703.	282.	26.0	15.0

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	11	12	4	4	4	4	4
AVERAGE	21.6	145.8	99.6	31.15	5.30	41.45	6.87
ST. DEV.	9.6	63.4	5.4	1.46	.44	5.54	1.22
MIN. VAL.	8.1	50.5	93.4	29.50	4.60	35.30	5.32
MAX. VAL.	37.4	206.5	105.5	32.70	5.60	45.70	8.00

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	4	1	1	1	1	1	1
AVERAGE	.692	60.000	.380	15.760	.673	11.016	.100
ST. DEV.	.226						
MIN. VAL.	.396	60.000	.380	15.760	.673	11.016	.100
MAX. VAL.	.950	60.000	.380	15.760	.673	11.016	.100

	TOTAL PO MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	4	12	12	12	10	12	12
AVERAGE	.54	18.50	4.14	14.37	2.274	.023	12.45
ST. DEV.	.18	6.04	2.99	6.71	3.717	.024	9.00
MIN. VAL.	.29	3.96	1.12	2.54	.004	.004	.15
MAX. VAL.	.70	28.34	10.77	24.87	9.550	.067	24.87

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	12	12	12	4	4
AVERAGE	4.769	4.153	39.4	15.2	17.7
ST. DEV.	1.709	1.508	8.7	1.1	2.7
MIN. VAL.	1.029	.725	16.4	13.7	13.6
MAX. VAL.	6.385	6.030	49.2	16.4	19.4

ANNUAL AVERAGE WATER QUALITY

PARAMETER	RANGE OF VALUES		UNITS
DATE	10/ 1/81 -	9/31/82	MO/DA/YR
DEPTH	0.0 -	0.0	METERS
SAMPLE	0.	1.	TYPE

STATION = WHALEY CANAL

	TEMP CENT	D.O. MG/L	PH	SP COND UMHOS/CM	COLOR UNITS	TURB NTU	T[illegible]
NUM. VALS.	10	10	9	9	10	10	[illegible]
AVERAGE	21.7	3.8	5.80	159.	[illegible]	3.6	[illegible]
ST. DEV.	4.9	2.2	.76	61.	94.	2.1	[illegible]
MIN. VAL.	14.5	1.7	4.75	78.	71.	.7	[illegible]
MAX. VAL.	28.4	8.9	7.21	273.	[illegible]	7.6	[illegible]

	TOTORG C MG/L	ALKCACO3 MG/L	HARDNESS MG/LCACO	CA MG/L	MG MG/L	NA MG/L	K MG/L
NUM. VALS.	9	10	3	3	3	3	3
AVERAGE	26.4	13.9	26.1	5.47	3.03	13.90	1.69
ST. DEV.	9.4	11.6	9.2	1.92	1.00	2.26	1.17
MIN. VAL.	20.7	5.0	16.3	3.40	1.90	11.30	.40
MAX. VAL.	44.6	43.5	34.4	7.20	4.00	15.40	2.70

	F MG/L	TDISS ZN MICROG/L	TDISS CD MICROG/L	TDISS CU MICROG/L	TDISS PB MICROG/L	TDISS MN MICROG/L	TDISS SR MG/L
NUM. VALS.	3	1	1	1	1	1	1
AVERAGE	.076	16.000	.439	2.630	.400	.241	.100
ST. DEV.	.011						
MIN. VAL.	.064	16.000	.439	2.630	.400	.241	.100
MAX. VAL.	.084	16.000	.439	2.630	.400	.241	.100

	TOTAL FE MG/L	TOTAL N MG N/L	TKN-NH4 MG N/L	NOX+NH4 MG N/L	NO3 MG N/L	NO2 MG N/L	NH4 MG N/L
NUM. VALS.	3	10	10	10	10	10	10
AVERAGE	.56	2.06	1.98	.08	.010	.007	.07
ST. DEV.	.35	.95	.87	.12	.013	.003	.12
MIN. VAL.	.23	.67	.61	.01	.004	.004	.01
MAX. VAL.	.93	3.92	3.51	.41	.045	.014	.41

	TPO4 MG P/L	OPO4 MG P/L	CL MG/L	SIO2 MG/L	SO4 MG/L
NUM. VALS.	10	10	10	3	3
AVERAGE	.066	.006	18.6	3.3	14.0
ST. DEV.	.044	.009	10.2	2.5	3.6
MIN. VAL.	.026	.002	4.0	.6	11.5
MAX. VAL.	.179	.031	36.4	5.6	18.3

APPENDIX D

DEFINITION OF TERMS

APPENDIX D

Term Definitions

1. Flow-Weighted Concentration: This term is equal to the material load for given time period divided by the total flow for the same period.

2. Areal Loading Rate (L_P, L_N or L_C): This term is equal to the material load for a given time period divided by the surface area of the receiving lake.

3. Water Residence Time (τ_ω): This term is equal to the lake water volume divided by the surface outflows (excluding evaporation). This represents the period of time that water is present in a lake with respect to nutrients, since nutrients are not lost by evapotranspiration.

4. Hydraulic Loading Rate (q_S): This term is calculated by dividing the surface water inflows (excluding rainfall) by the surface area of the lake. This represents the height (m/yr) that the surface inflows would raise the lake level during a year, assuming no loss of water through evapotranspiration or outflow.

5. Other Sinks: This term is computed as the difference between the total inflow, total outflow, and change in storage terms and represents the combined effects from unmeasured inflows, unmeasured outflows, and the analytical and hydrological error associated with the budget.

6. Error (Q): This term equals the other sinks term divided by the lake volume times 100 and represents the percent over or underestimation of the water budget to predict a change in the lake volume based upon inflows and outflows.

7. Error (chloride):

   $$\text{This term} = \left(\frac{\text{(Other Cl sinks (tonnes) X 810.7360)}}{\text{(Avg. lake conc. (mg/L) X avg. lake volume)}} \right) 100$$

   Since chloride is a conservative variable, the chloride budget theoretically should equal the water budget in its ability to account for all additions and losses of this ion over time and is a good accuracy check.

APPENDIX E

LIST OF DOMINANT AND COMMON PHYTOPLANKTON SPECIES FOR THE UPPER KISSIMMEE CHAIN OF LAKES

EAST LAKE TOHOPEKALIGA

AND

LAKES TOHOPEKALIGA, CYPRESS, HATCHINEHA, AND KISSIMMEE

TABLE E-1

LIST OF DOMINANT AND COMMON* PHYTOPLANKTON SPECIES OBSERVED FROM EAST LAKE TOHO.

EAST LAKE TOHO PHYTOPLANKTON APRIL-OCTOBER 1982	
<u>Myxophyceae</u> (Blue-greens)	
Anacystis incerta	
Aphanizomenon flos-aquae	
Lyngbya limnetica	D
Schizothrix calcicola (El)	
<u>Chlorophyceae</u> (Green Algae)	
Ankistrodesmus convolutus	A
Chlorella sp.	
Chlorococcum sp.	
Dimorphococcus lunatus	
Dictyosphaerium sp.	A
Dictyosphaerium pulchellum	
Golenkinia radiata	A
Pediastrum boryanum	
Scenedesmus sp. 1	
Scenedesmus abundans	
Scenedesmus acuminatus	
Scenedesmus quadricauda	
<u>Desmids</u>	
Staurastrum sp. 1	
Staurastrum dejectum	
<u>Bacillariophyceae</u> (Diatoms)	
Melosira granulata	D
Melosira granulata v. angustissima	
Rhizosolenia sp. 1	
<u>Chrysophyceae</u>	
Dinobryon divergens	A
Mallomonas caudata	
Ophiocytium captitatum	
<u>Dinophyceae</u> (Dinoflagellates)	
Peridinium cinctum	A
Peridinium sp. 2	D
<u>Euglenophyceae</u>	
Euglena sp.	

<u>Footnote:</u>
* Includes species comprising >1% of the total population
D = found as a dominant species at one or more sites
A = found in great abundance (but not a dominant species) at one or more sites

TABLE E-2

LIST OF DOMINANT AND COMMON* PHYTOPLANKTON SPECIES OBSERVED FROM LAKES TOHO, CYPRESS, HATCHINEHA, AND KISSIMMEE.

KISSIMMEE CHAIN OF LAKES PHYTOPLANKTON APRIL-OCTOBER 1982	
<u>Myxophyceae</u> (Blue-greens)	
Agmenellum sp.	
Anabaena sprioides	D
Anacytis cyanea	A
Anacystis incerta	A
Anacystis montana	A
Aphanizomenon flos-aquae	
Gomphospheria lacustris	A
Lyngbya contorta	D
Lyngbya limnetica	A
Microcoleus lyngbyacus	
Raphidiopsis curvata	
Schizothrix calcicola (El)	A
<u>Chlorophyceae</u> (Green Algae)	
Ankistrodesmus falcatus v. acicularis	A
Chlamydomonas spp.	
Chlorococcum sp.	
Coelastrum spp.	
Dictyosphaerium pulchellum	A
Dimorphococcus lunatus	A
Elaktothrix gelatinosa	
Golenkinia radiata	A
Hormidium klebsii	
Kirchneriella contorta	
Kirchneriella subsolitaria	
Micratinium pusillum	
Chodatella subsalsa	
Oocystis spp.	
Pediastrum boryanum	
Pediastrum duplex v. gracillium	
Pediastrum simplex	
Pediastrum tetras	
Scenedesmus abundans	A
Scenedesmus abundans v. longicauda	
Scenedesmus acuminatus	
Scenedesmus brasiliensis	
Scenedesmus denticulatus	
Scenedesmus dimorphus	A
Scenedesmus hystrix	
Scenedesmus obliqus	
Scenedesmus longus	
Scenedesmus parisiensis	
Scenedesmus quadricauda	D
Scenedesmus quadricauda v. maxima	A
Tetraedron trigonum	
Tetrastrum staurogeniaeforme	

TABLE E-2 (Continued)

Desmids	
Closterium cf. acutum	
Euastrum sp. 1	
Staurastrum sp. 1	
Staurastrum lativenter	
Bacillariophyceae (Diatoms)	
Cyclotella menghiniana	
Fragillaria construens	A
Fragillaria construens v. subsalina	
Fragillaria pinnata	A
Melosira distans	A
Melosira granulata	D
Melosira granulata v. angustissima	A
Nitzschia sp.	
Nitzschia acicularis	
Rhizosolenia sp. 1	
Stephanodiscus astraea v. minutula	
Stephanodiscus invisitatus	
Chrysophyceae	
Dinobryon spp.	
Mallonomas caudata	
Dinophyceae (Dinoflagellates)	
Peridinium sp. 2	
Peridinium cintum	
Euglenophyceae	
Euglena sp.	
Phacus sp.	
Trachelomonas	
Cryptophyceae	
Cryptomonas sp.	

Footnote:
* Includes species comprising >1% of the total population
D = found as a dominant species at one or more sites
A = found in great abundance (but not a dominant species) at one or more sites

Blue-green references: Drouet and Daily (1956), Drouet (1968, 1973); green algae references, Prescott (1952), Whitford and Schumacher (1973), G.M. Smith (1933); Diatom reference, Hustedt (1930), Patrick and Reimer (1966, 1973).